3.2 Geological, Paleontological, and Mineral Resources

The proposed project covers several physiographic provinces including the Wyoming Basins, Colorado Plateau, Middle Rocky Mountains, and Basin and Range provinces. The proposed routes cross a variety of bedrock and surficial deposits that also include geologic hazards. Mineral resources in the areas crossed by the proposed Project include oil and natural gas, coal, aggregate and industrial minerals.

3.2.1 Regulatory Background

3.2.1.1 Geological Resources

Regulations pertaining to geological resources are concerned with the preservation of unique geological features. The National Registry of Natural Landmarks (16 USC 461-467) set up the National Natural Landmarks (NNL) program in 1962 and is administered under the Historic Sites Act of 1935. Implementing regulations were first published in 1980 under 36 CFR 1212 and the program was re-designated as 36 CFR 62 in 1981. A National Natural Landmark is defined as:

- An area designated by the Secretary of the Interior as being of national significance to the United States because it is an outstanding example(s) of major biological and geological features found within the boundaries of the United States or its Territories or on the Outer Continental Shelf (36 CFR 62.2).
- An area designated as one of the best examples of a biological community or geological feature within a natural region of the United States, including terrestrial communities, landforms, geological features and processes, habitats of native plant and animal species, or fossil evidence of the development of life (36 CFR 62.2).

<u>Geological Hazards</u>

Various federal and state regulations provide design standards for facilities located in areas that may have potentially damaging ground movements due to movement on active or potentially active faults, or landslides.

3.2.1.2 Paleontological Resources

Federal legislative protection for paleontological resources stems from the Antiquities Act of 1906 (P.L. 59-209; 16 U.S.C. 431 et seq.; 34 Stat. 225), which calls for protection of historic landmarks, historic and prehistoric structures, and other objects of historic or scientific interest on federally administered lands. Federal protection for scientifically important paleontological resources would apply to construction or other related project impacts that would occur on federally owned or managed lands. This act provides for funding of mitigation of paleontological resources discovered during federal aid highway projects, provided that “excavated objects and information are to be used for public purposes without private gain to any individual or organization.” In addition to the foregoing, the National Registry of Natural Landmarks provides protection to paleontological resources. The BLM manages paleontological resources (fossils) on federal lands under the following statutes and regulations (BLM 2012a):

- FLPMA (P.L. 94-579);
- NEPA (P.L. 91-190);
- Title 43 of the CFR (Public Lands:Interior) (addresses the collection of invertebrate, vertebrate and plant fossils); and
- The Paleontological Resources Preservation Act of 2009 (P.L.111-011). The law authorizes the BLM and USFS and other land management agencies of the federal government to manage and provide protection to fossil resources using “scientific principles and expertise.” The act defines

paleontological resource as “any fossilized remains, traces, or imprints of organisms, preserved in or on the earth’s crust, that are of paleontological interest and that provide information about the history of life on earth.”

In addition to the statutes and regulations listed above, fossils on public lands are managed according to internal BLM guidance and manuals. BLM Manual 8270 (BLM 1998a) and the BLM Handbook H-8270-1 (BLM 1998b) contain the BLM's policy and guidance for the management of paleontological resources on public land and information. The manual presents information on the authorities and regulations related to paleontological resources. The handbook gives procedures for permit issuance, requirements for qualified applicants, and information on paleontology and planning. Important guidance for the protection of paleontological resources is contained in IM 2009-011 which provides guidelines for the assessment and mitigation of impacts to paleontological resources (BLM 2008a). Other IMs include WO-IM-2012 140 and 141 (BLM 2012a,b).

The USFS also manages paleontological resources, but under the NFMA and NEPA.

3.2.1.3 Mineral Resources

Federally-owned minerals in the public domain are classified into specific categories and these categories only apply to minerals in the federal mineral estate. Because most of the mineral estate in the project area is owned by the federal government, it is important to identify the mineral commodity classifications used by the BLM and the USFS. Within legal constraints, publicly-owned minerals are available for exploration, development, and production, while subject to existing regulations, standard terms and conditions, and stipulations. These categories are locatable minerals, leasable, and salable minerals. The classifications listed below are based on Acts passed by the U.S. Congress.

- Locatable minerals include precious and base metallic ores and nonmetallic minerals such as bentonite, gypsum, chemical grade limestone, and chemical grade silica sand. Uncommon varieties of sand, gravel, building stone, pumice, rock, and cinders also are managed as locatable minerals. Locatable minerals are acquired under the General Mining Law of 1872, as amended and the Surface Use and Occupancy Act of July 23, 1955 (American Geological Institute 1997).
- Leasable minerals are those minerals that are leased to individuals for exploration and development. The leasable minerals have been subdivided into two classes, fluid and solid. Fluid minerals include oil and gas, geothermal resources and associated by-products, oil shale, native asphalt, oil impregnated sands, and any other material in which oil is recoverable only by special treatment after the deposit is mined or quarried. Solid leasable minerals are specific minerals such as coal and phosphates. Leasable minerals are associated with the following laws; Mineral Leasing Act of 1920, as amended and supplemented, Mineral Leasing Act for Acquired Lands of 1947, as amended, and the Geothermal Steam Act of 1970, as amended (American Geological Institute 1997). Leasable minerals are acquired by applying to the federal government for a lease to explore and develop the minerals.
- Salable minerals are common mineral materials that include sand, gravel, roadbed, ballast, and common clay and are sold by contract with the federal government. These have been identified as all other minerals that were not designated as leasable or locatable. These minerals are regulated under the Mineral Material Act of July 23, 1947, as amended, and the Surface Use and Occupancy Act of July 23, 1955 (American Geological Institute 1997).

3.2.2 Data Sources

Data sources include published maps and reports and internet websites of the U.S. Geological Survey (USGS) and UGS. Other data sources included academic and professional journals and publications. Specific reference citations are provided within the text and a complete description of each reference is provided in reference section of the document.

3.2.3 Analysis Area

The analysis area for geology, minerals, and paleontological resources generally encompasses the area within the 2-mile transmission line corridor. However, the Baseline Description includes general descriptions of the physiography, geology, paleontological resources, and mineral resources of the regions where the alternatives are located in order to provide a sense of the geological setting.

3.2.4 Baseline Description

3.2.4.1 Physiography and Geology

The proposed project covers several physiographic provinces including the Wyoming Basins, Colorado Plateau, Middle Rocky Mountains, and Basin and Range (Fenneman 1928).

The Wyoming Basins province covers 40,000 square miles in much of central and southwestern Wyoming and a portion of northwestern Colorado (Howard and Williams 1972). The province is characterized by basins, small mountain ranges, plateaus, and mesas where elevations generally range from 6,000 to 7,000 feet above mean sea level (amsl) in the basins to more than 8,000 feet amsl elevation in the mountain ranges. The area is semi-arid and playas, deflation basins, sands dunes, and badlands are common features.

In the Wyoming Basins section, the bedrock formations generally consist of Upper Cretaceous and Lower Tertiary rocks. Surficial materials consist of recent and older quaternary alluvium, colluvium and terrace deposits. Also present are sand dunes, playa deposits, and landslide material. Various structural features are present in the Wyoming Basins, including (from east to west) the Hanna Basin, Rawlins Uplift, southeast Greater Green River Basin (including the Washakie and Sand Wash Basins), and the Axial Arch (Grose 1972). Among the major structural features are numerous smaller structural features including folds and faults.

The Colorado Plateau province is 140,000 square miles in area and covers portions of Utah, Colorado, Arizona, and New Mexico (Howard and Williams 1972). The plateau is semi-arid to arid and landforms typically consist of highly dissected plateaus and mesas and badland topography.

Within the Colorado Plateau province are the Uinta Basin, High Plateaus of Utah, and Canyonlands sections of the Colorado plateau province (Fenneman 1928). The Uinta Basin is a strong-relief, dissected plateau where elevations range from about 5,000 to 7,000 feet amsl. The High Plateaus of Utah section is characterized by elevated and dissected block plateaus and terrace plateaus covered in part by volcanic flows. The High Plateaus of Utah is a transition zone between the Colorado Plateau and the Basin and Range province to the west because the area has characteristics of both provinces (Utah Geological Survey [UGS] 2011a). The High Plateaus of Utah section is rugged and elevations range from about 7,000 to 10,000 feet amsl. The western portion of the Canyonlands section (west of the Green River) is characterized by eroded plateaus and high relief with elevations ranging from 5,000 to 7,000 amsl. From the Utah-Colorado state line to the Green River, elevations range from less than 4,300 amsl at the Green River to 5,000 amsl.

Bedrock in the Colorado Plateaus primarily consists of nearly-flat lying Cretaceous and Paleozoic rocks, but also includes Tertiary sedimentary rocks (in the Uinta Basin) and Tertiary and Quaternary volcanic rocks (UGS 2011a). Surficial deposits are not very extensive and primarily consist of alluvium, terraces, colluvium, and sand dunes. Major structural features include the Piceance Basin, Douglas Creek Arch, Uinta Basin, San Rafael Uplift, and the Wasatch Plateau. Within the larger structural features, there are smaller order structures including folds and faults.

The Middle Rocky Mountains province consists of mountain ranges of varying structural styles and origins (fault block, dissected volcanic plateau, shallow thrust sheets, or deep seated eroded anticlinal folds). The eastern extension of the Middle Rocky Mountain province is the Uinta Mountains. The Uinta Mountains are a large, deep-seated, breached anticline that trends east-west. Elevations in the eastern Uinta Mountains range from around 8,000 feet amsl along the crest of the range to approximately 6,500 feet amsl on the Wyoming side. In the Uinta Basin elevations are approximately 5,000 feet amsl. The Wasatch Range, which is the southern extremity of the Middle Rocky Mountain province, is a block-faulted mountain range with Mount Nebo being the highest point in the range at 11,877 feet amsl.

The major rock types exposed in the Uinta Mountains consist of Precambrian metamorphic sedimentary rocks (Hintze 1988). In the southern Wasatch Mountains the rocks consist of Tertiary volcanic and Upper Cretaceous rocks as well as intrusive masses of Jurassic-aged salt and gypsum containing highly deformed Jurassic to Quaternary deposits (Witkind and Weiss 1991).

The Great Basin section of the Basin and Range province is characterized by narrow, block-faulted mountain ranges that generally have a north-south trend and are separated by basins or valleys. In low-relief valleys such as the Pahroc-Delamar Valley, Dry Lake Valley, Tule Desert, Escalante Desert, Muddy River Valley, and Las Vegas Valley, elevations range from about 6,000 feet amsl in central Utah to 2,000 feet amsl near Las Vegas, Nevada. Mountain ranges include the Cedar Range, the Delamar Mountains, the Clover Mountains, Bull Valley Mountains, and the Beaver Dam Mountains, where elevations approach 7,000 feet amsl.

In the Great Basin, the alternatives cross primarily unconsolidated deposits of alluvium, alluvial fan, pediment, sand dune, lake sediments, and occasional outcrops of sedimentary Cambrian rocks (Hintze and Davis 2002; Hintze et al. 2003; Steven et al. 1990; Rowley et al. 2006). The alternatives also cross Tertiary volcanic lava flows and folded Mesozoic and Paleozoic rocks in southwest Utah. In the Nevada portion of the Great Basin, the alternatives cross Tertiary volcanic and sedimentary rocks, Precambrian rocks, Paleozoic limestone and dolomite, and Triassic sedimentary rocks (Tschanz and Pampeyan 1970; Longwell et al. 1965).

3.2.4.2 Geologic Hazards

Seismic Hazards

Seismic hazards occur as the result of energy that is released when there is movement on faults in the Earth’s crust that results in an earthquake. Seismicity refers to the frequency of earthquakes which varies with geographic location. A fault is a fracture whereby the ground on either side of the fracture has moved relative to one another, and parallel to the fracture (USGS 2009a). An active fault is a fault on which movement has occurred within the last 10,000 years. A quaternary fault is a fault where evidence indicates that movement has taken place within the last 1.6 million years, but no evidence of movement within the last 10,000 years.

An earthquake generates waves of energy that cause the ground to shake, even many miles from the site of the fault rupture. The USGS develops estimates of potential ground motion using the peak acceleration of ground motion expressed as a percentage of the acceleration of gravity (**g**) with a 10 percent probability of exceedance in 50 years (Petersen et al. 2008). This information is presented in map form (**Figure 3.2-1**) to provide an indication of potential seismic risk for regions to be crossed by the alternatives. This figure shows that ground motion is expected to be low except along the seismically active area along the Wasatch Mountains and High Plateaus of Utah.

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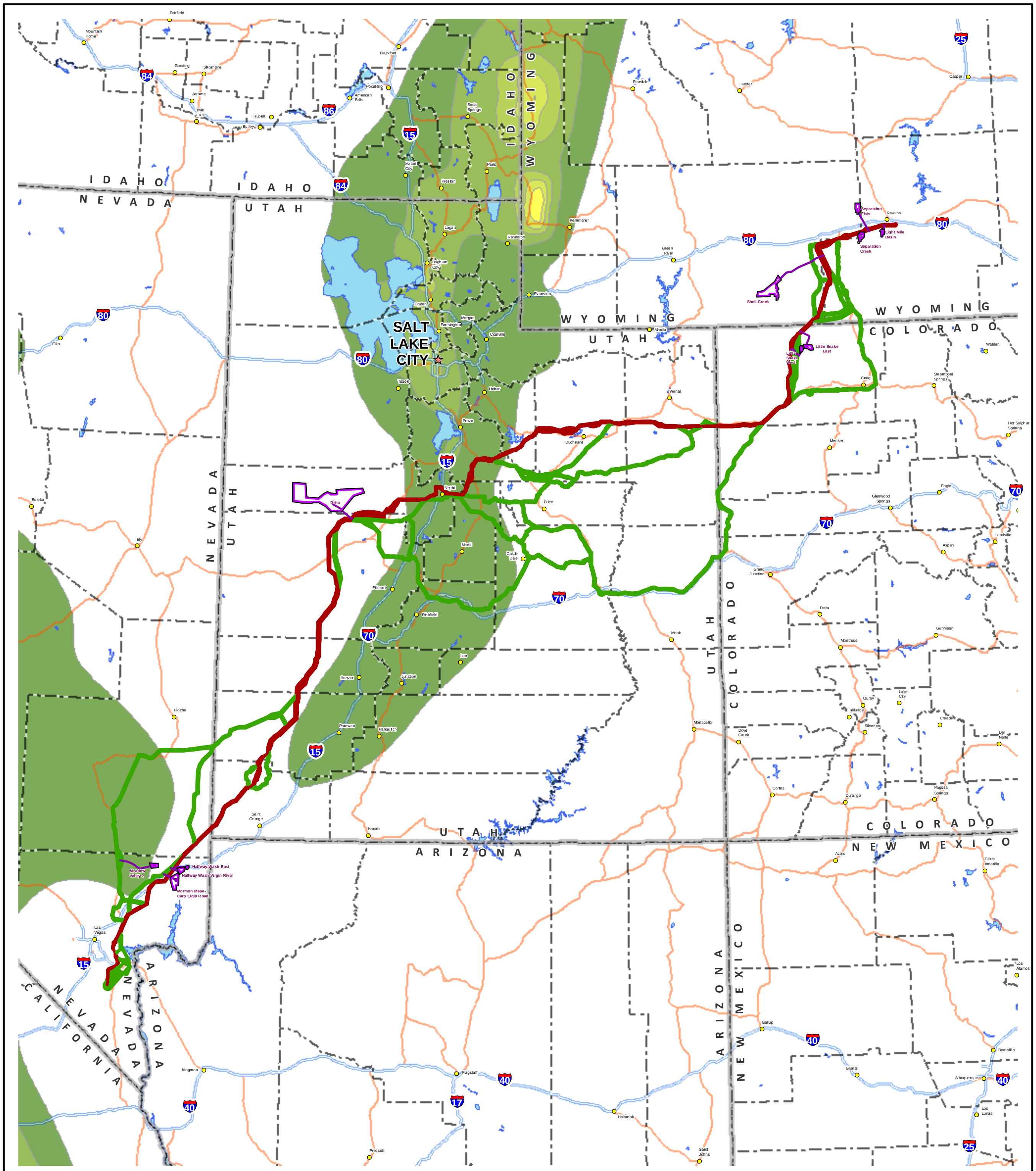

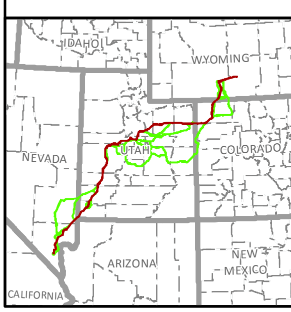

Project Corridors

- Applicant Proposed
- Alternative

Seismic Hazard

(Peak Ground Acceleration in % G)

- 10-15
- 15-20
- 20-25
- 25-30
- 30-40

- Potential Ground Electrode Siting Area
- Potential Ground Electrode Site
- Potential Ground Electrode Overhead Electrical Line

TRANSWEST EXPRESS TRANSMISSION PROJECT

Figure 3.2-1
Seismic Hazard

0 20 40 80 Miles
0 20 40 80 km
1:5,000,000

N

Western AREA POWER ADMINISTRATION

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Landslides

Landslide is a term used for various processes involving the movement of earth material down slopes (USGS 2004). Landslides can occur in a number of different ways in different geological settings. Large masses of earth become unstable and by gravity begin to move downhill. The instability can be caused by a combination of factors including steep slopes, periods of high precipitation, undermining support by natural processes (stream erosion), or unintentional undercutting or undermining the strength of unstable materials in the construction of roads and structures.

The degree of landslide hazard is defined on the basis of landslide incidence and degree of landslide susceptibility as determined by the USGS in (Radbruch-Hall et al. 1982). Geologic map units or portions of map units "with more than 15 percent of their area involved in landsliding were classified as having high incidence; those with 1.5 to 15 percent of their area involved in landsliding, as having medium incidence; and those with less than 1.5 percent of their area involved, as having low incidence." Landslide susceptibility has been defined as "the probable degree of response of the areal rocks and soils to natural or artificial cutting or loading of slopes or to anomalously high precipitation. High, medium, and low susceptibility are delimited by the same percentages used in classifying the incidence of landsliding" (i.e., high greater than 15 percent, medium 1.5 to 15 percent, and low, less than 1.5 percent). The project area contains, for the most part, areas of low landslide incidence and susceptibility, but there are areas of high susceptibility and incidence of landslides, especially in central Utah.

Subsidence

Subsidence is a decrease of surface elevation of the ground and may be caused by a variety of phenomena including, but not limited to, dissolution of subsurface strata, compaction, removal of groundwater, and earthquake ground motion. The surface expression from subsidence can range from localized precipitous collapses (sinkholes) to broad regional lowering of the earth's surface. Sinkholes have been identified in the North Horn Formation in the Wasatch Plateau area and the Scipio Valley (Bjorkland and Robinson 1968; Gillette and Miller 1999). Other causes of subsidence are underground mining and subsidence due to groundwater withdrawal. Subsidence due to coal mining may be a hazard in the coal resource and mining areas that are crossed. Subsidence due to groundwater withdrawal may be of greatest concern in southwestern Utah.

3.2.4.3 Paleontological Resources

The BLM has adopted the PFYC system to identify and classify fossil resources on federal lands (BLM 2007). Paleontological resources are closely tied to the geologic units (i.e., formations, members, or beds) that contain them. The probability for finding paleontological resources can be broadly predicted from the geologic units present at or near the surface. Therefore, geologic mapping can be used for assessing the potential for the occurrence of paleontological resources. The alternatives cross bedrock that has the potential to contain valuable paleontological resources. The various geographic regions have formations that have yielded high value fossils, especially vertebrates such as dinosaurs and mammals. The formations also contain valuable invertebrate and plant fossils.

The PFYC system is a way of classifying geologic units based on the relative abundance of vertebrate fossils or scientifically significant fossils (plants, vertebrates, and invertebrates) and their sensitivity to adverse impacts. A higher class number indicates higher potential. The PFYC is not intended to be applied to specific paleontological localities or small areas within units. Although important localities may occasionally occur in a geologic unit, a few widely scattered important fossils or localities do not necessarily indicate a higher class; instead, the relative abundance of significant localities is intended to be the major determinant for the class assignment. The PFYC system is meant to provide baseline guidance for predicting, assessing, and mitigating paleontological resources. The classification should be considered at an intermediate point in the analysis and should be used to assist in determining the need for further mitigation assessment or actions. The BLM intends for the PFYC system to be used as a guideline as opposed to rigorous definitions. Descriptions of the potential fossil yield classes are summarized in **Table 3.2-1**.

Table 3.2-1 Potential Fossil Yield Classification

Class	Description	Basis	Management Considerations
1	Very low potential. Geologic units not likely to contain recognizable fossil remains. Rocks such as igneous or metamorphic units, (excluding reworked volcanic ash units) and units that are Precambrian in age or older.	The probability for impacting any fossils is negligible. Assessment or mitigation of paleontological resources is usually unnecessary. The occurrence of significant fossils is non-existent or extremely rare.	Management concern for paleontological resources in Class 1 units is usually negligible or not applicable. Assessment or mitigation is usually unnecessary except in very rare or isolated circumstances.
2	Low Potential. Sedimentary geologic units which are not likely to contain paleontological resources. Included in Class 2 are rock units or geologic deposits have the following characteristics: Vertebrate or significant invertebrate or plant fossils not present or very rare; units that are generally younger than 10,000 years before present; recent aeolian deposits; and sedimentary rocks that exhibit significant physical and chemical changes (i.e., diagenetic alteration).	The probability for impacting vertebrate fossils or paleontological resources is low. Assessment or mitigation of paleontological resources is not likely to be necessary. Localities containing important resources may exist, but would be rare and would not influence the classification. These important localities would be managed on a case-by-case basis.	Management concern for paleontological resources is generally low and assessment or mitigation is usually unnecessary except in rare or isolated circumstances.
3a, 3b	Moderate or Unknown Potential. Fossiliferous sedimentary geologic units where fossil content varies in significance, abundance, and predictable occurrence; or sedimentary units of unknown fossil potential. Class 3 units include the following types of geologic units: • Often marine in origin with sporadic known occurrences of vertebrate fossils. • Vertebrate fossils and scientifically important invertebrate or plant fossils known to occur intermittently; predictability known to be low. • Poorly studied and/or poorly documented. Potential yield cannot be assigned without ground reconnaissance. **Class 3a** – Moderate Potential. Units are known to contain paleontological resources, but these occurrences are widely scattered. Common invertebrate or plant fossils may be found in the area, and opportunities may exist for hobby collecting. The potential for a project to be sited on or impact a significant fossil locality is low, but is somewhat higher for common fossils.	This classification includes a broad range of paleontological potential. It includes geologic units of unknown potential, as well as units of moderate or infrequent occurrence of paleontological resources. Surface-disturbing activities may require field assessment to determine whether significant paleontological resources occur in the area of a proposed action, and whether the action could affect the paleontological resources. These units may contain areas that would be appropriate to designate as hobby collection areas due to the higher occurrence of common fossils and a lower concern about affecting significant paleontological resources.	Management concern for paleontological resources is moderate or cannot be determined from existing data. Management considerations cover a broad range of options as well, and could include pre-disturbance surveys, monitoring, or avoidance. Surface-disturbing activities will require sufficient field assessment to determine appropriate course of action.

Table 3.2-1 Potential Fossil Yield Classification

Class	Description	Basis	Management Considerations
3a, 3b (continued)	**Class 3b** – Unknown Potential. Units exhibit geologic features and preservational conditions that suggest paleontological resources, but little information about the paleontological resources of the unit or the area is known. This may indicate the unit or area is poorly studied, and field surveys may uncover significant finds. The units in this Class may eventually be placed in another Class when sufficient survey and research is performed. The unknown potential of the units in this Class should be carefully considered when developing any mitigation or management actions.		
4a,b	High Potential. Geologic units containing a high occurrence of paleontological resources. Vertebrate fossils or scientifically significant invertebrate or plant fossils are known to occur and have been documented, but may vary in occurrence and predictability. Surface disturbing activities may adversely affect paleontological resources in many cases. Class 4 units have the following characteristics: • Extensive soil or vegetative cover; bedrock exposures are limited or not expected to be impacted. • Areas of exposed outcrop are smaller than two contiguous acres. • Outcrops form cliffs of sufficient height and slope so that impacts are minimized by topographic conditions. • Other characteristics are present that lower the vulnerability of both known and unidentified paleontological resources. **Class 4a** – Unit is exposed with little or no soil or vegetative cover. Outcrop areas are extensive with exposed bedrock areas often larger than two acres. Paleontological resources may be susceptible to adverse impacts from surface disturbing actions. Illegal collecting activities may impact some areas.	The probability for impacting paleontological resources is moderate to high, and is dependent on the proposed action. Mitigation considerations must include assessment of the disturbance, such as removal or penetration of protective surface alluvium or soils, potential for future accelerated erosion, or increased ease of access resulting in greater looting potential. If impacts to significant fossils can be anticipated, on-the-ground surveys prior to authorizing the surface disturbing action will usually be necessary. On-site monitoring or spot-checking may be necessary during construction activities.	Management concern for paleontological resources in Class 4 is moderate to high, depending on the proposed action. A field survey by a qualified paleontologist is often needed to assess local conditions. Management prescriptions for resource preservation and conservation through controlled access or special management designation should be considered. Class 4 and Class 5 units may be combined as Class 5 for broad applications, such as planning efforts or preliminary assessments, when geologic mapping at an appropriate scale is not available. Resource assessment, mitigation, and other management considerations are similar at this level of analysis, and impacts and alternatives can be addressed at a level appropriate to the application.

Table 3.2-1 Potential Fossil Yield Classification

Class	Description	Basis	Management Considerations
4a,b (continued)	**Class 4b** – These are areas underlain by geologic units with high potential but have lowered risks of human-caused adverse impacts and/or lowered risk of natural degradation due to moderating circumstances. The bedrock unit has high potential, but a protective layer of soil, thin alluvial material, or other conditions may lessen or prevent potential impacts to the bedrock resulting from the activity.		
5a,b	Very High Potential. Highly fossiliferous geologic units that consistently and predictably produce paleontological resources, and that are at risk of human caused adverse impacts or natural degradation. Class 5 units have the following characteristics: • Extensive soil or vegetative cover; bedrock exposures are limited or not expected to be impacted. • Areas of exposed outcrop are smaller than two contiguous acres. • Outcrops form cliffs of sufficient height and slope so that impacts are minimized by topographic conditions. • Other characteristics are present that lower the vulnerability of both known and unidentified paleontological resources. **Class 5a** – Unit is exposed with little or no soil or vegetative cover. Outcrop areas are extensive with exposed bedrock areas often larger than two contiguous acres. Paleontological resources are highly susceptible to adverse impacts from surface disturbing actions. Unit is frequently the focus of illegal collecting activities. **Class 5b** – These are areas underlain by geologic units with very high potential but have lowered risks of human-caused adverse impacts and/or lowered risk of natural degradation due to moderating circumstances. The bedrock unit has very high potential, but a protective layer of soil, thin alluvial material, or other conditions may lessen or prevent potential impacts to the bedrock resulting from the activity.	The probability for impacting significant fossils is high and fossils known or can reasonably be expected to occur in the impacted area. On-the ground surveys prior to authorizing any surface disturbing activities will usually be necessary. On-site monitoring may be necessary during construction activities.	Management concern for paleontological resources in Class 5 areas is high to very high. A field survey by a qualified paleontologist is usually necessary prior to surface disturbing activities or land tenure adjustments. Mitigation will often be necessary before and/or during these actions. Official designation of areas of avoidance, special interest, and concern may be appropriate.

Source: BLM 2007.

3.2.4.4 Mineral Resources

Mineral resources in the various regions include metallic ores (gold, silver, and copper), non-metallic deposits (sand, gravel, and gypsum), geothermal, coal, and hydrocarbons (oil and natural gas). The following subsections provide a summary of the mineral resources found in each region.

3.2.5 Regional Description

3.2.5.1 Region I

Physiography and Geology

Region I is primarily located in the Wyoming Basins and Colorado Plateau physiographic provinces; a small portion in Utah and Wyoming also crosses the Middle Rocky Mountain province (**Figure 3.2-2**) (Fenneman 1928).

In Wyoming, Region I is located in the Hanna Basin and the southeast portion of the Greater Green River Basin (within the Wyoming Basins physiographic area). The basins contain thousands of feet of sedimentary rocks and were created during the formation of the Rocky Mountains in late Cretaceous and early Tertiary time. Bedrock is composed of Triassic, Jurassic, Cretaceous and Tertiary rocks (Love and Christensen 1985). The Cretaceous units include the Niobrara, Steel Shale, Mesaverde, Lewis, and Lance formations. The Cretaceous rocks consist of marine shale, sandstones, mudstones, and minor coal beds (Watson 1980). Tertiary units crossed are the Fort Union, Ferris, and Hanna formations that consist of non-marine, continental, and fluvial (river) deposits of sandstone, conglomerate, mudstones, carbonaceous shales, and coal. South of Wamsutter, Wyoming, the bedrock consists of mainly Tertiary Fort Union, Wasatch, and Green River formations. In Colorado, the bedrock units are the Wasatch and Green River formations, the Mancos shale, Mesaverde, and Miocene Browns Park formations.

Geological Hazards

Seismic Hazards

Region I is an area of low earthquake activity. There are no active faults in the Colorado and Wyoming portions of Region I and the routes in these states do not cross any quaternary faults (USGS 2006; USGS and Colorado Geological Survey 2006). The USGS seismic hazard mapping indicates that in areas crossed by the corridors in Region I, ground movement that could be triggered by a maximum credible earthquake is expected to be low, having a peak ground acceleration (PGA) of less than 10 percent of the acceleration of **g** with a 10 percent probability of exceeding that PGA in 50 years (Petersen et al. 2008).

Landslides

In Region I, there are areas of moderate to high susceptibility and low incidence in Wyoming and northwestern Colorado. **Figure 3.2-3** shows the landslide areas in Region I. The upper Cretaceous and Tertiary formations are particularly susceptible to movement and landslides.

Subsidence

Alternates cross areas of current and historic underground coal mining and these areas may be subject to ground subsidence. Specific areas crossed by the 2-mile transmission line corridors are discussed under the Mineral Resources topic for Region I.

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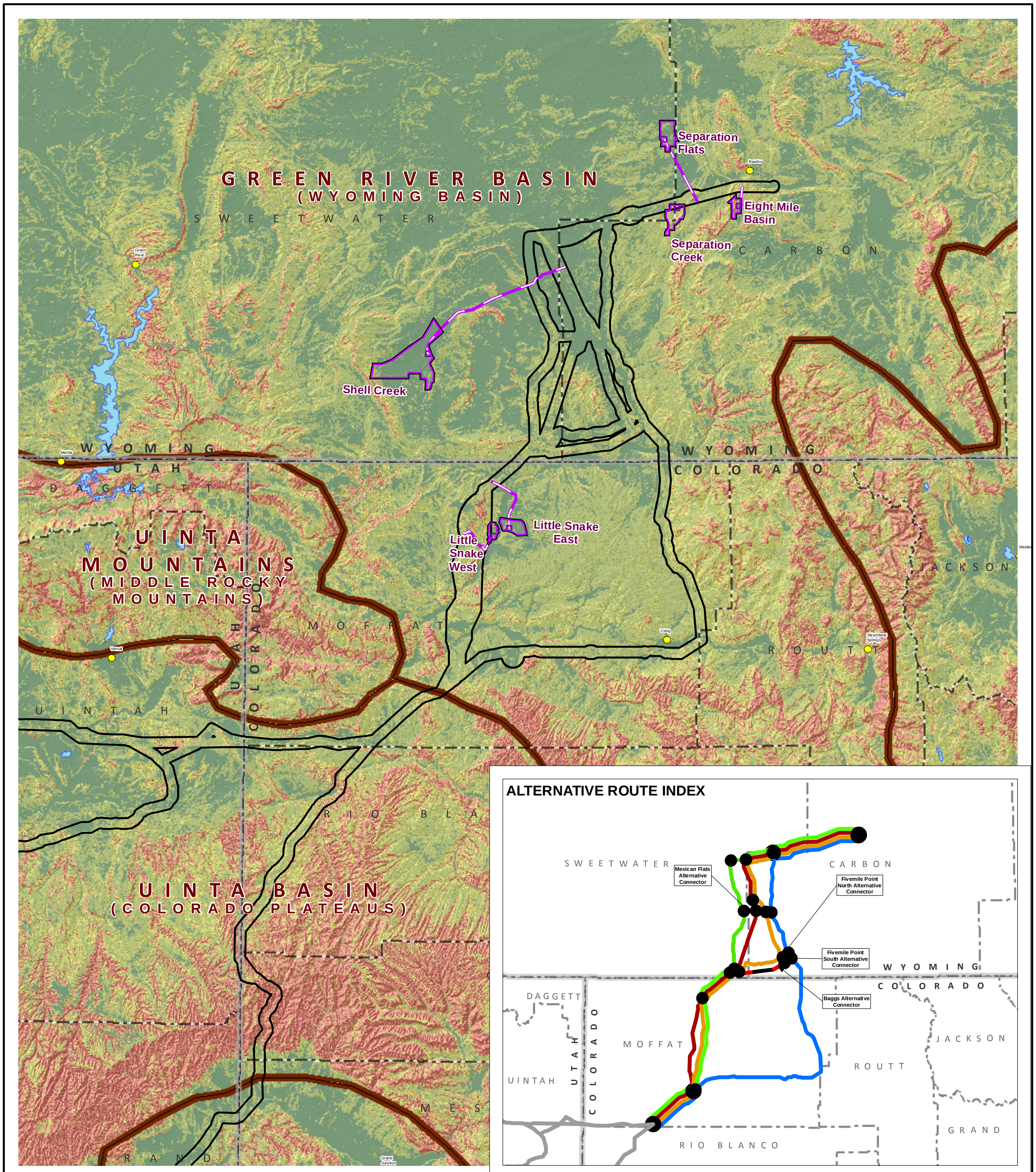

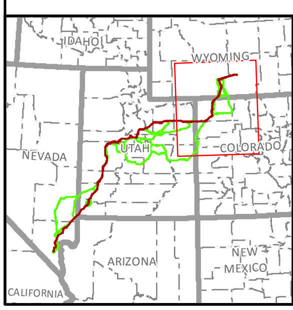

Project Corridor

DEIS Alternative Routes

- Applicant Proposed I-A
- Alternative I-B
- Alternative I-C
- Agency Preferred I-D
- Alternative Variation or Connector
- Segment not in this Region

Potential Ground Electrode Siting Area

Potential Ground Electrode Site

Potential Ground Electrode Overhead Electrical Line

Physiographic Section (Province)

Topography

- Flat (<5%)
- Rolling (5-15%)
- Steep (15-25%)
- Rugged (>25%)

TRANSWEST EXPRESS TRANSMISSION PROJECT

Figure 3.2-2
Region I
Physiography and Topography

0 5 10 20 Miles
0 5 10 20 km
1:1,750,000

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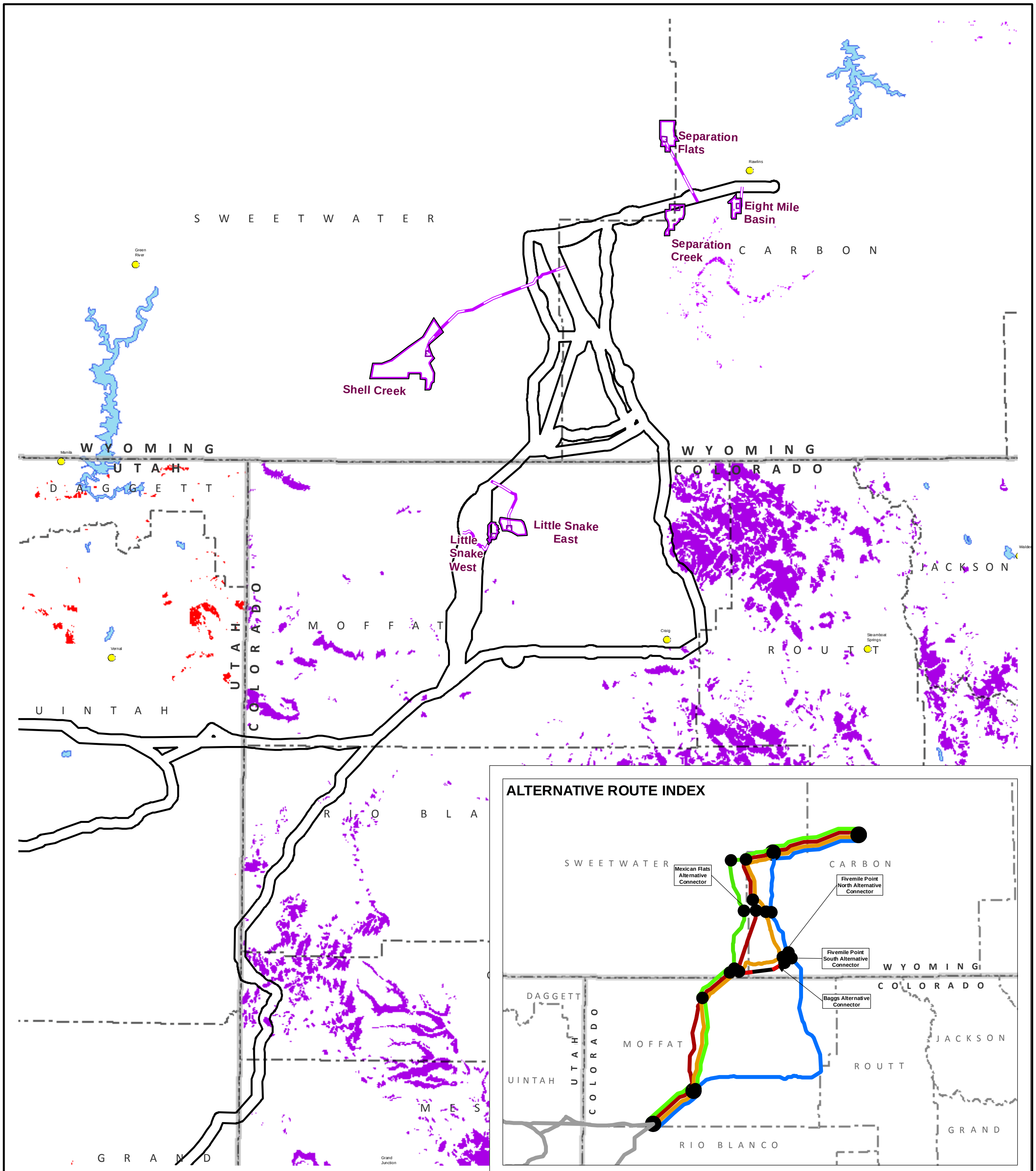

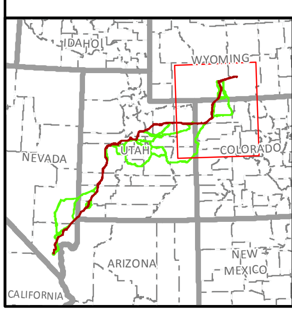

Project Corridor

DEIS Alternative Routes

- Applicant Proposed I-A
- Alternative I-B
- Alternative I-C
- Agency Preferred I-D
- Alternative Variation or Connector
- Segment not in this Region

- Potential Ground Electrode Siting Area
- Potential Ground Electrode Site
- Potential Ground Electrode Overhead Electrical Line
- Unclassified Landslide (CO & WY)

TRANSWEST EXPRESS TRANSMISSION PROJECT

Figure 3.2-3
Region I
Landslide Incidence

0 5 10 20 Miles
0 5 10 20 km
1:1,750,000

N

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Paleontological Resources

In Region I, there are a number of important fossil bearing formations. **Table 3.2-2** lists the formations in order of relative age and provides the PFYC ratings for the formations or geologic units. **Figure 3.2-4** shows the PFYC ratings crossed in Region I. Dinosaur National Monument, an outstanding fossil resource, is located in Region I a few miles east of Vernal, Utah.

Table 3.2-2 Potential Fossil-bearing Formations and PFYC Classifications in Region I

Formation/Rock Unit	Age	PFYC Rank
Browns Park	Miocene to Pliocene	3-5
Bishop Conglomerate	Oligocene	3
Duchesne River	Eocene to Oligocene	5
Washakie Formation	Eocene	5
Battle Spring Formation	Eocene	3
Uinta Formation	Upper Eocene	4
Green River Formation and Parachute Creek and Douglas Creek Members	Eocene	4-5
Wasatch Formation	Lower Eocene	5
Hanna Formation	Lower Eocene	5
Fort Union	Paleocene	3
Ferris Formation	Paleocene	3-5
Medicine Bow Formation	Upper Cretaceous	3
Lance Formation	Upper Cretaceous	5
Lewis Shale	Upper Cretaceous	3
Williams Fork	Upper Cretaceous	5
Iles Formation	Upper Cretaceous	4
Mesaverde Group or Formation	Upper Cretaceous	3-5
Steele Shale	Upper Cretaceous	3
Niobrara Shale	Upper Cretaceous	5
Sego Sandstone of the Mancos Shale	Upper Cretaceous	3
Frontier Formation	Upper Cretaceous	3
Dakota Formation	Lower Cretaceous	5
Madison Formation	Devonian- Mississippian	3

Sources: BLM 2012b, 2008b; USDOE and USDOI 2008.

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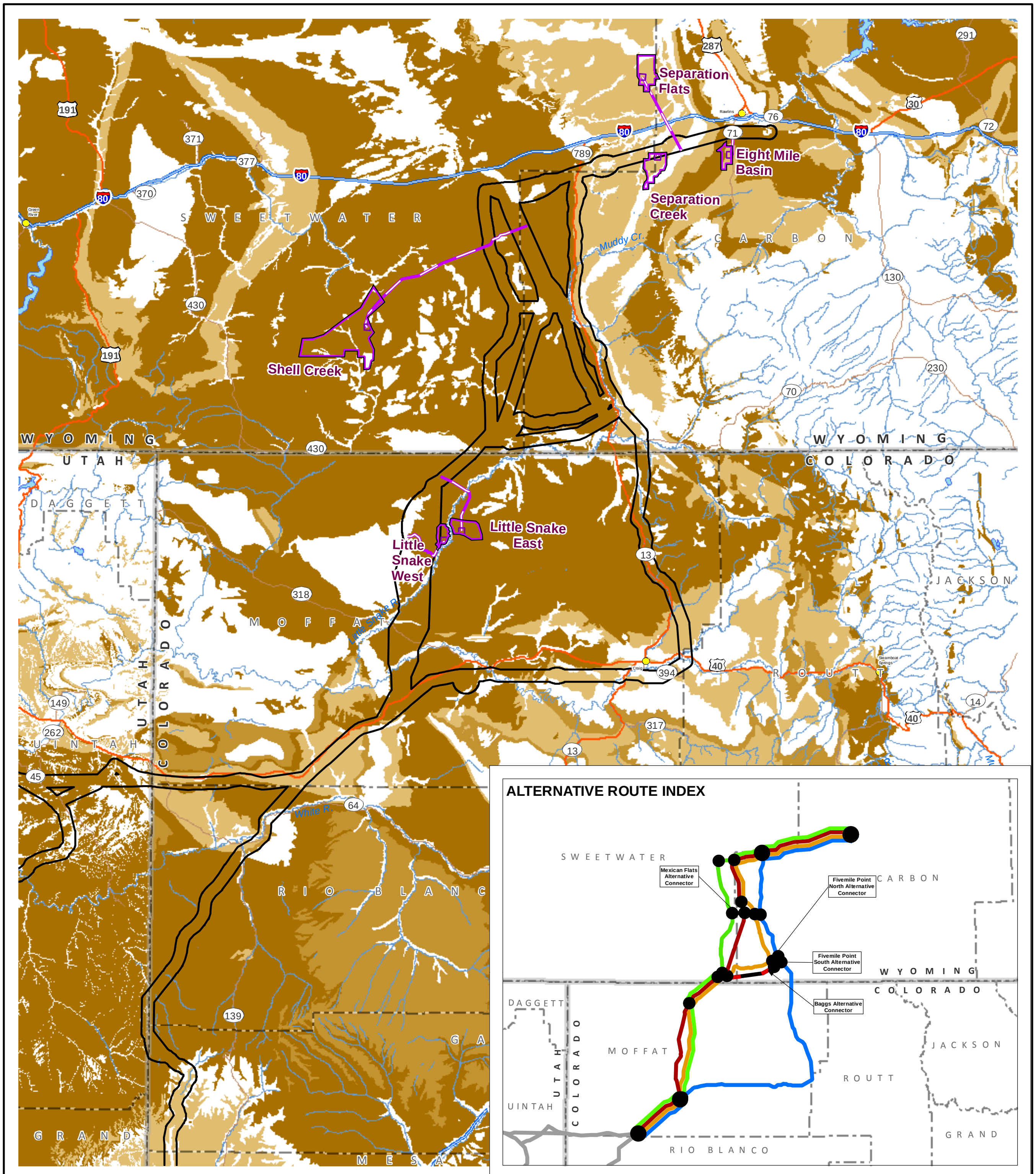

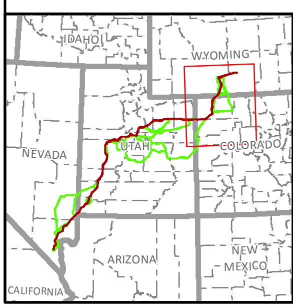

Project Corridor

DEIS Alternative Routes

- Applicant Proposed I-A
- Alternative I-B
- Alternative I-C
- Agency Preferred I-D
- Alternative Variation or Connector
- Segment not in this Region

Potential Ground Electrode Siting Area

Potential Ground Electrode Site

Potential Ground Electrode Overhead Electrical Line

Potential Fossil Yield Class (PFYC)

- Class 3
- Class 4
- Class 5

TRANSWEST EXPRESS TRANSMISSION PROJECT

Figure 3.2-4
Region I
Potential Fossil Yield Classes

0 5 10 20 Miles
0 5 10 20 km
1:1,500,000

N

Western Area Power Administration

Exported On: 6/5/2013

Mineral Resources

The major mineral resources in the study area are oil, natural gas, and coal. The Green River Basin is a prolific area of natural gas production, but oil also is an important resource. The Uinta Basin also has a large resource of oil and natural gas. Coal bed methane is a potentially important resource in the region (BLM 2010). The analysis area crosses numerous oil and gas fields, especially in the Wyoming portion of the region (De Bruin 2007; Wray et al 2002). **Table 3.2-3** lists the oil and gas fields crossed by the proposed and alternative 2-mile transmission line corridors in Region I. Coal also is an important resource; portions of the Green River Coal Region are located within Region I. Alternative 2-mile transmission line corridors cross the following coal fields in Region I: Hanna, Kindt, Great Divide, Rock Springs, Yampa, and Lower White River (Biewick 2012; Carrol 2004; Tabet and Wakefield 2006). **Figure 3.2-5** depicts the oil and gas fields and coal mines in Region I.

Table 3.2-3 Oil and Gas Fields Crossed by Alternatives in Region I

Alternative I-A	State	Alternative I-B	State	Alternative I-C	State	Alternative I-D	State
Unnamed	Wyoming	Unnamed	Wyoming	Unnamed	Wyoming	Unnamed	Wyoming
Cont. Divide- Creston	Wyoming	Cont. Divide- Creston	Wyoming	Cont. Divide- Creston	Wyoming	Cont. Divide-Creston	Wyoming
Cedar Breaks	Wyoming	Fairway	Wyoming	Blue Gap	Wyoming	Cedar Breaks	Wyoming
Fireplace Rock	Wyoming	Mulligan Draw	Wyoming	Craig North	Colorado	Blue Gap	Wyoming
Round Table	Colorado	Dripping Rock	Wyoming	Buck Peak	Colorado	Round Table	Colorado
Powder Wash	Colorado	Cedar Breaks	Wyoming	Craig	Colorado	Powder Wash	Colorado
Elk Springs	Colorado	McPherson Springs	Wyoming	Bell Rock	Colorado	Elk Springs	Colorado
		Stateline	Wyoming	Elk Springs	Colorado		
		Stateline	Colorado				
		North Big Hole	Colorado				
		Big Hole	Colorado				
		Elk Springs	Colorado				

Sources: DeBruin 2007; Wray et al. 2002.

The Alternative I-C (Segment 190.00) 2-mile transmission corridor crosses a coal planning area and there are tracts in the Craig, Colorado, area that have been identified as suitable for coal leasing (BLM 1980). However, the corridor does not cross any of these potential coal lease tracts. The segment also crosses areas of abandoned coal mines located in Sections 9, 10, and 20 in Township 6 North, Range 90 West; and Section 9, Township 6 North, Range 91 west; 2 to 3 miles south and southwest of Craig, Colorado (Colorado Geological Survey 2011). There is subsidence associated with these historic abandoned coal mines.

Other mineral resources in Region I include oil shale and aggregate (sand, gravel, and crushed stone).

3.2.5.2 Region II

Physiography and Geology

Region II is located in the Colorado Plateau, Middle Rocky Mountains, and the Basin and Range provinces (**Figure 3.2-6**) (Fenneman 1928).

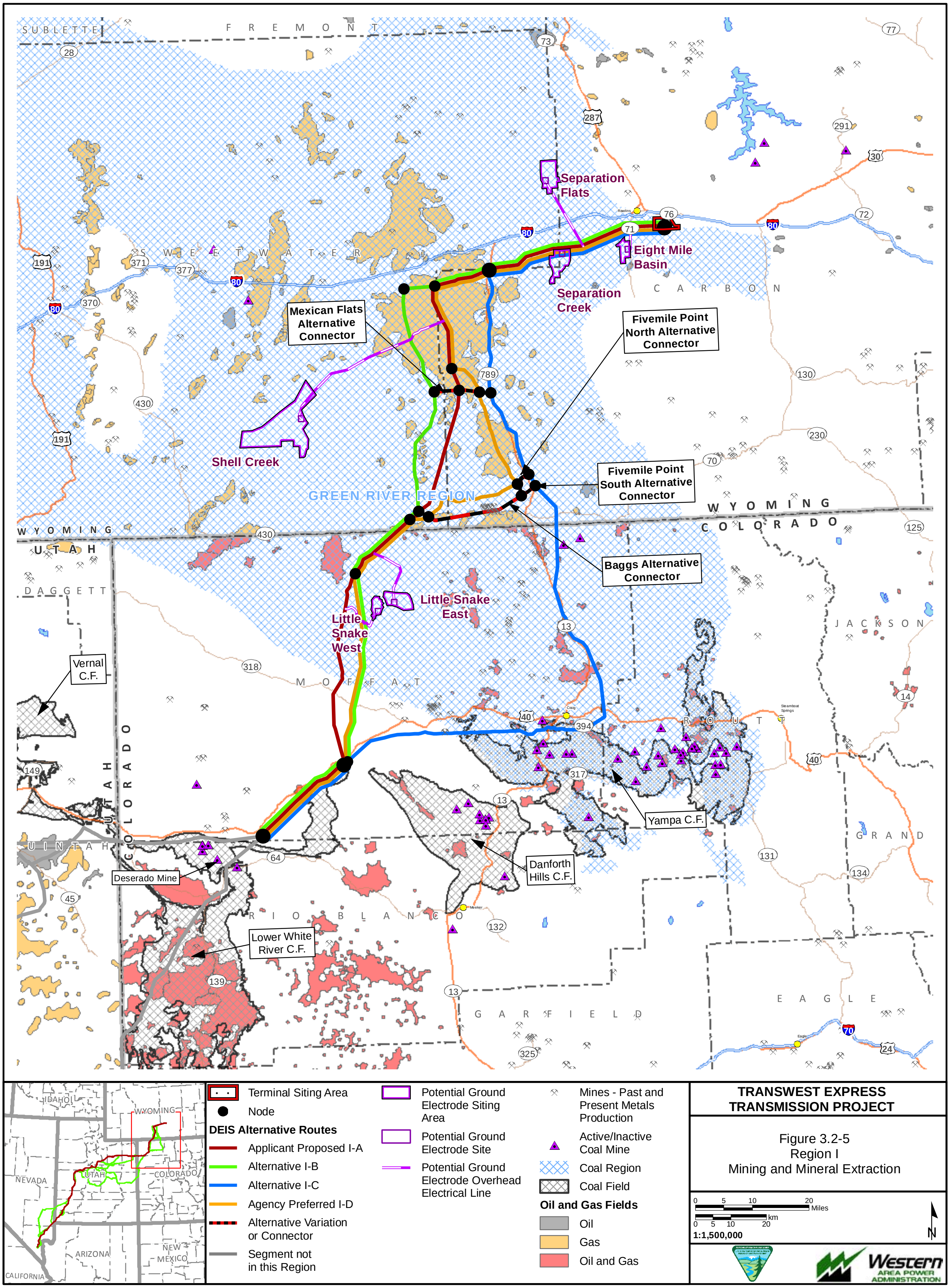

Figure 3.2-5
Region I
Mining and Mineral Extraction

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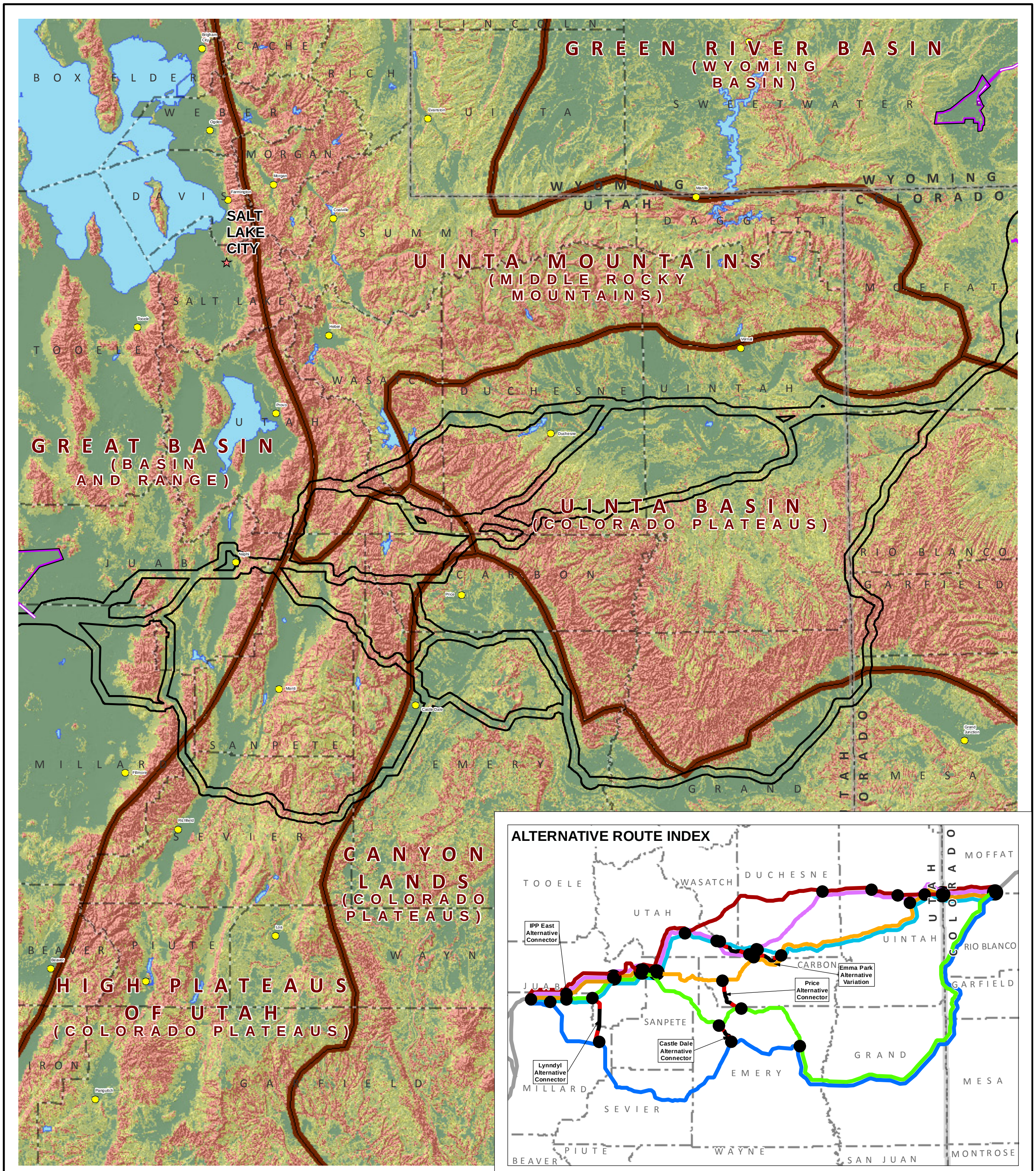

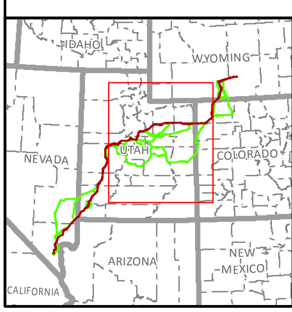

Project Corridor

DEIS Alternative Routes
- Applicant Proposed II-A
- Alternative II-B
- Alternative II-C
- Alternative II-D
- Alternative II-E
- Agency Preferred II-F
- Alternative Variation or Connector
- Segment not in this Region
- Physiographic Section (Province)

- Potential Ground Electrode Siting Area
- Potential Ground Electrode Site
- Potential Ground Electrode Overhead Electrical Line

Topography
- Flat (<5%)
- Rolling (5-15%)
- Steep (15-25%)
- Rugged (>25%)

TRANSWEST EXPRESS TRANSMISSION PROJECT

Figure 3.2-6
Region II
Physiography and Topography

0 10 20 40 Miles
0 10 20 40 km
1:2,250,000

N

Exported On: 6/5/2013

In Region II, the alternative 2-mile transmission line corridors cross bedrock mainly composed of Cretaceous and Tertiary-age rocks, but also cross older Mesozoic and Paleozoic rocks in the western portions of the region. The major structural elements crossed include the Piceance Basin, Douglas Creek Arch, Uinta Basin, San Rafael Uplift, Wasatch Plateau, and the Sevier Orogenic Belt (Grose 1972).

The alternative 2-mile transmission line corridors II-A, II-D, II-E, and II-F cross Mesaverde equivalents in Colorado. After entering Utah, the 2-mile transmission line corridors cross Wasatch, Green River, and Duchesne formations (Sprinkle 2007). The Duchesne, Uinta, and Green River formations are crossed to west of the Wasatch-Utah County line (Bryant 1992; Constenius et al. 2006). On the Wasatch Plateau, alternative 2-mile transmission line corridors cross the North Horn, Flagstaff Limestone, Moroni, and Park City formations. Region II also contains coalesced alluvial fan and alluvial deposits.

Near IPP, the 2-mile transmission line corridor alternatives primarily cross alluvium, alluvial fan, sand dunes, and lake deposits. The Prospect Mountain Quartzite, Dome Limestone, and Fish Haven Dolomite also are crossed.

Along the Colorado-Utah border, the alternative 2-mile transmission line corridors II-B and II-C cross the Mancos Shale, Mesaverde, and Mesaverde equivalents (Cashion 1973). The 2-mile transmission line corridors also cross Wasatch and Green River formations. In west-central Utah, the 2-mile transmission line corridors cross Mancos Shale, other upper Cretaceous units, and limited exposures of the Morrison formation until crossing the Green River (Williams 1964). West of the Green River, the 2-mile transmission line corridors cross the Navajo Sandstone, Carmel formation, Morrison formation, Dakota Sandstone, and Mancos shale. Also crossed in central Utah is the Arapian Shale (Williams and Hackman 1971; Hintze and Davis 2002).

<u>Geological Hazards</u>

Seismic Hazards

Seismic activity in Utah occurs along a line that stretches north to south in the central part of the state from the Salt Lake area and south, then southwest to the southwest corner of the state (**Figure 3.2-7**). The line corresponds to the Wasatch Mountains in the northern part of the state and along the hingeline that marks the boundary between the Great Basin and Colorado Plateau. This area of earthquake activity along the Wasatch Mountains and the hingeline that divides the state is referred to as the Intermountain Seismic Belt (Machette et al. 2004).

Region II contains a number of potentially active fault zones and includes Stinking Springs, Wasatch, Joes Valley, Little Valley, Scipio Valley, Sugarville, Pavant Range, and Maple Grove fault zones (USGS and UGS 2006).

Except for areas along the Intermountain Seismic Belt, ground motion hazard mapping indicates that there is a low potential for ground motion to cause serious damage from a maximum earthquake that could be predicted for the area (**Figure 3.2-1**). However, in the southern Wasatch Mountains, ground motion could damage vulnerable buildings (Christenson 1994).

Landslides

Along the High Plateaus of Utah, the alternative 2-mile transmission line corridors cross areas of moderate to high incidence and susceptibility to landslides (Radbruch-Hall et al. 1982; Giraud et al. 2007). **Figure 3.2-8** shows the landslide incidence in Region II. The North Horn, Green River, and Duchesne formations are primarily responsible for the slope instability in this area, but other formations may be involved too, especially Cretaceous rocks with numerous bentonite clay layers that can become unstable during periods of high precipitation. All alternative 2-mile transmission line corridors cross areas of high landslide incidence and potential.

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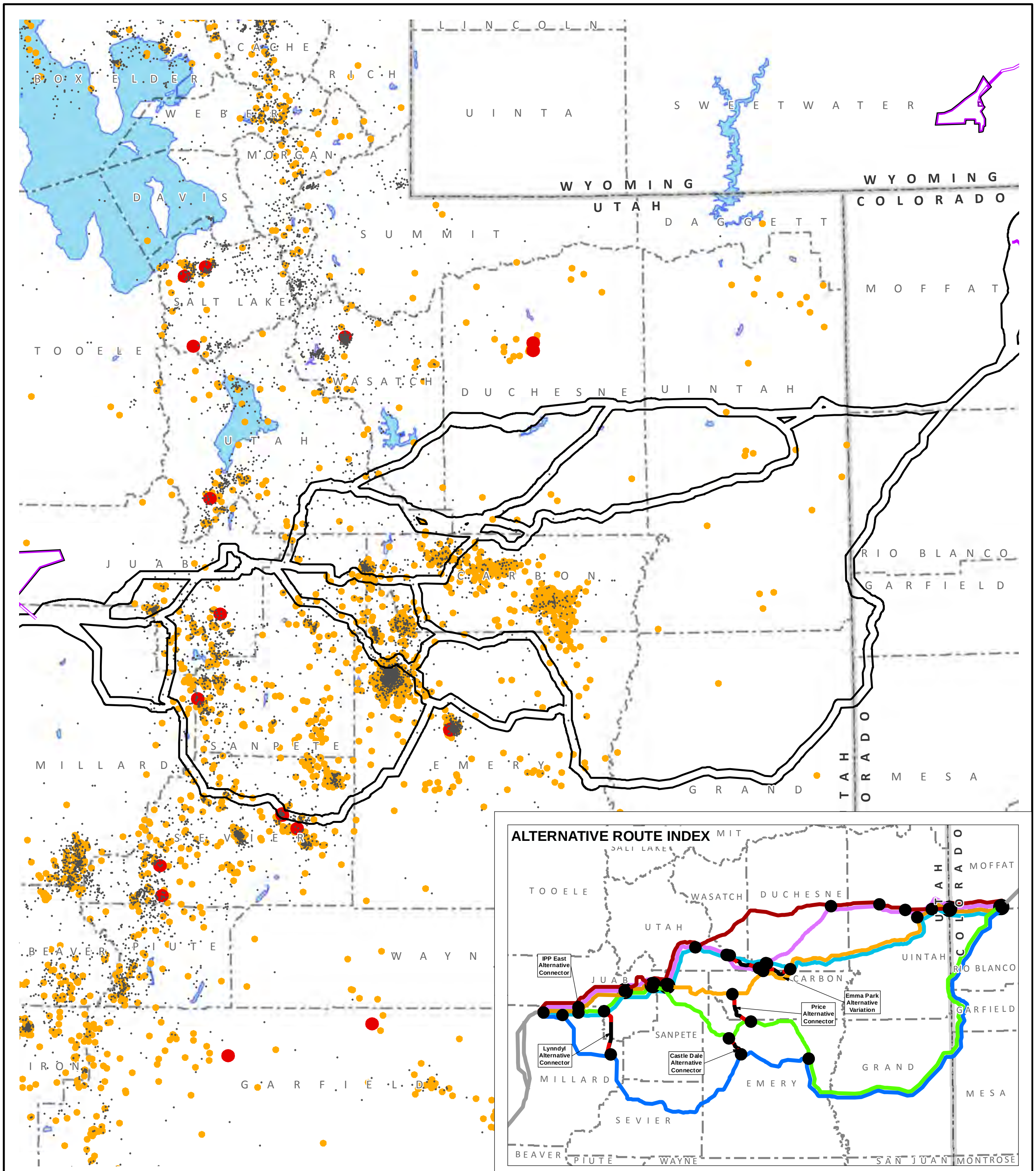
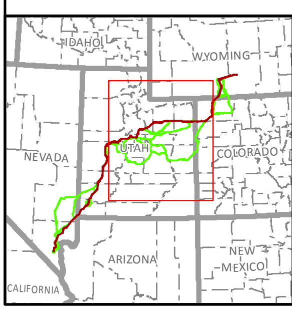




Project Corridor

DEIS Alternative Routes

- Applicant Proposed II-A
- Alternative II-B
- Alternative II-C
- Alternative II-D
- Alternative II-E
- Agency Preferred II-F
- Alternative Variation or Connector
- Segment not in this Region

Potential Ground Electrode Siting Area

Potential Ground Electrode Site

Potential Ground Electrode Overhead Electrical Line

Magnitude (Richter)

- <2
- 2 - 4
- > 4

TRANSWEST EXPRESS TRANSMISSION PROJECT

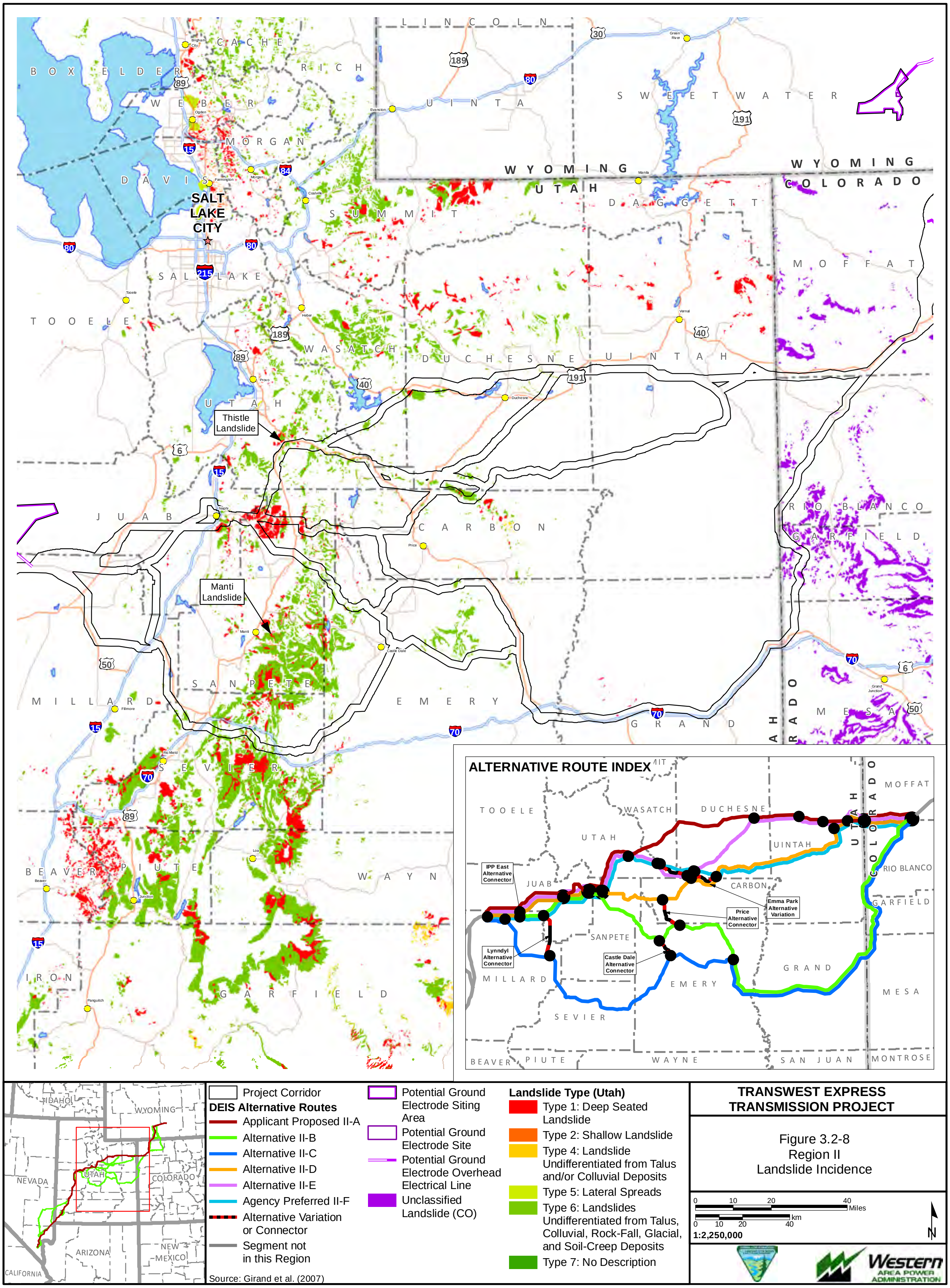
Figure 3.2-7
Region II
Seismic Activity: 1965-1993

0 10 20 40 Miles
0 10 20 40 km
1:2,250,000

N

Western Area Power Administration

Exported On: 4/9/2013



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Subsidence

The analysis area within Region II crosses areas underlain by carbonate or evaporite rocks and sinkholes have been identified in the North Horn Formation on the Wasatch Plateau and Scipio Valley in central Utah (Bjorkland and Robinson 1968; Gillette and Miller 1999). Alternate 2-mile transmission line corridors do, however, cross areas of current and historic underground coal mining and these areas may be subject to ground subsidence. Specific areas crossed by 2-mile transmission line corridors are discussed under the Mineral Resources topic for Region II.

Paleontological Resources

The alternative 2-mile transmission line corridors in Region II cross a number of important fossil bearing formations. **Table 3.2-4** lists the formations in order of relative age and provides the PFYC ratings for the formations or geologic units. **Figure 3.2-9** shows the PFYC ratings crossed in Region II. Formations in Region II have the potential to have world-class fossil resources as demonstrated by the Cleveland-Lloyd Dinosaur Quarry National Landmark located 20 miles east of Huntington, Utah (BLM 2009). Where alternative 2-mile transmission line corridors cross from the Wasatch Plateau to the lake beds of ancient Lake Bonneville, there is a potential to cross old shore lines left by fluctuations of lake levels during the Pleistocene (1.8 million to 10,000 years ago). Although, sand and gravel deposits associated with old lake shorelines may have fossil resources, the shoreline deposits have a PFYC ranking of 2 (BLM 2008c).

Table 3.2-4 Potential Fossil-bearing Formations and PFYC Classifications in Region II

Formation/Rock Unit	Age	PFYC Rank
Lake Bonneville Shoreline Deposits	Pleistocene	2
Duchesne River	Eocene to Oligocene	5
Uinta Formation	Eocene	5
Green River Formation, Douglas Creek and Parachute Creek members	Middle to Lower Eocene	5
Wasatch Formation	Lower Eocene	5
Flagstaff Limestone	Paleocene	5
North Horn	U. Cretaceous-L. Tertiary	5
Mesaverde Group or Formation[1]	Upper Cretaceous	3-5
Farrer Formation	U. Cretaceous	4-5
Neslen Formation	U. Cretaceous	4-5
Tuscher Formation	Cretaceous	3
Mancos Shale	Upper Cretaceous	3
Indianola Group	Cretaceous	3
Dakota Sandstone	Lower Cretaceous	3
Cedar Mountain	Lower Cretaceous	5
Morrison Formation	Jurassic	5
Carmel Formation	Jurassic	3
Curtis Formation	Jurassic	3
Navajo Sandstone	Jurassic	3
Kayenta	Jurassic	3-5
Chinle Formation	Upper Triassic	4
Moenkopi	Middle to Lower Triassic	3
Kaibab	Permian	3
White Rim Sandstone	Permian	3
Cutler Formation (Cedar Mesa Member)	Lower Permian	3

Table 3.2-4 Potential Fossil-bearing Formations and PFYC Classifications in Region II

Formation/Rock Unit	Age	PFYC Rank
Hermosa Group	Pennsylvanian	3
Humbug Formation	Mississippian	2
Deseret Formation	Mississippian	2
Wheeler Formation	Cambrian	Not determined (ND)
Swasy Limestone	Cambrian	ND
Whirlwind Formation	Cambrian	ND
Dome Limestone	Cambrian	ND
Chisholm Formation	Cambrian	ND
Howell Limestone	Cambrian	ND
Pioche Formation	Cambrian	ND

[1] Includes Price River Formation, Castlegate Sandstone, Blackhawk Formation, Star Point Sandstone.

Sources: BLM 2008d,e; USDOE and USDOI 2008; Western Trilobite Association.

Mineral Resources

The major mineral resources in Region II are oil, natural gas, coal, oil shale, and uranium. Numerous oil and gas fields of the Uinta Basin are within the Region II. **Figure 3.2-10** shows the oil and gas fields and coal mines in Region II. **Table 3.2-5** lists the oil and gas fields crossed by alternative 2-mile transmission line corridors in Region II. Coal is an important resource in Region II as well as coalbed methane.

In Utah, the Emery, Wasatch, and Book Cliffs coal fields are located in the region and coal is actively mined in several locations (UGS 1983; Chidsey et al. 2006; Bon and Wakefield 2008). The Book Cliffs form the southern boundary of the Uinta Basin and the Emery Coal Field is located in the east side of the Wasatch Plateau and the Wasatch coals field is collocated with the Wasatch Plateau. Both coal fields coincide with coal resources in upper Cretaceous rocks that outcrop along these features. Alternative II-D 2-mile transmission line corridor crosses active and inactive coal mining areas as well as potential coal development areas in the Book Cliffs and Wasatch coal fields in Carbon County, Utah (Township13 North, Ranges 6 through 10 East; BLM 2008d). Further south in the Wasatch coal field, Alternative II-B 2-mile transmission line corridor crosses active and historical coal mining areas and potential coal development areas northwest of Huntington, Utah (UGS 2012). The Alternative II-C 2-mile transmission line corridor encroaches on the east side of the Emery coal mine active permit area (Utah Division of Oil, Gas, and Mining [UDOGM] 2011).

In northwest Colorado, the Deserado Mine is located in the Lower White River coal field (Carroll 2004) (**Figure 3.2-5**). Alternatives II-A, II-D, II-E, and II-F 2-mile transmission line corridors cross just north of, and may slightly encroach on, areas proposed for leasing and expansion of the Deserado Mine in Township 3 North, Range 101 West (BLM 2011). Within the aforementioned corridors, there are historic coal mines northwest of the Deserado Mine in Township 3 North, Range 102 West (Carroll 2004). No information was available concerning whether subsidence has occurred or even if these are underground mines (Colorado Geological Survey 2011). Alternative II-B and II-C 2-mile transmission line corridors cross portions of the mine permit area of the Deserado Mine that have previously been mined in Township 2 North, Range 101 West. South of the Deserado Mine, the alternatives cross historic mining areas in Township 1 North, Ranges 101 and 102 West (Sullivan 1984).

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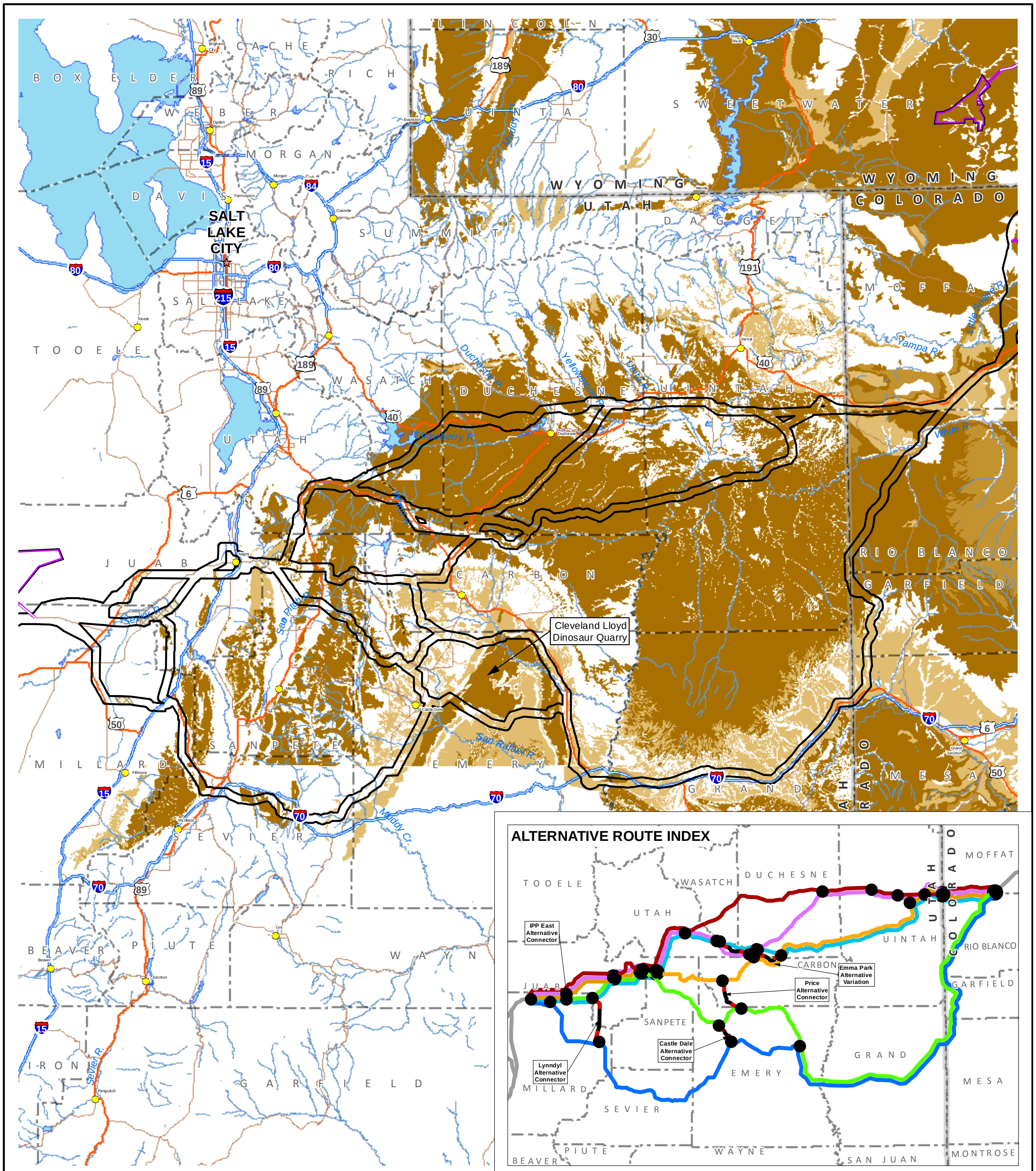

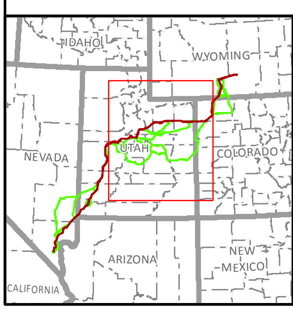

Project Corridor

DEIS Alternative Routes

- Applicant Proposed II-A
- Alternative II-B
- Alternative II-C
- Alternative II-D
- Alternative II-E
- Agency Preferred II-F
- Alternative Variation or Connector
- Segment not in this Region

Potential Ground Electrode Siting Area

Potential Ground Electrode Site

Potential Ground Electrode Overhead Electrical Line

Potential Fossil Yield Class (PFYC)

- Class 2 (Lake Bonnevile Shorelines)
- Class 3
- Class 4
- Class 5

TRANSWEST EXPRESS TRANSMISSION PROJECT

Figure 3.2-9
Region II
Potential Fossil Yield Classes

0 10 20 40 Miles
0 10 20 40 km
1:2,250,000

N

WESTERN AREA POWER ADMINISTRATION

Exported On: 6/6/2013

Note: PFYC data is derived from digital geologic data as available and digitized from hard copy geologic maps as needed. Through a combination of these two methods, there is complete PFYC coverage of the TWE Project.

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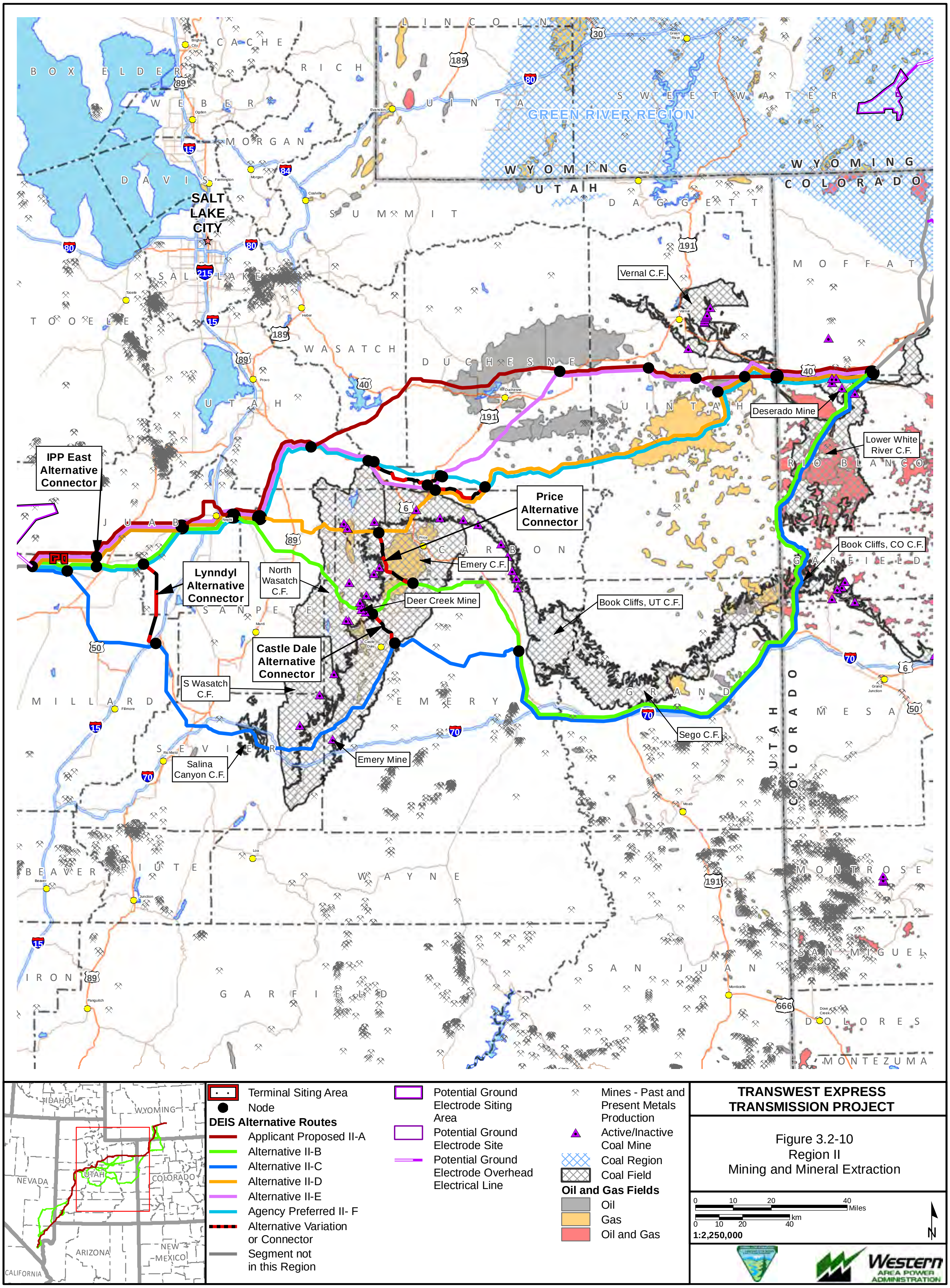

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Table 3.2-5 Oil and Gas Fields Crossed by Alternatives in Region II

Alternative II-A	State	Alternative II-B	State	Alternative II-C	State	Alternative II-D	State	Alternative II-E	State	Alternative II-F	State
Dinosaur	Colorado	Rangely	Colorado	Rangely	Colorado	Dinosaur	Colorado	Dinosaur	Colorado	Dinosaur	Colorado
Red Wash	Utah	Rangely Southwest	Colorado	Rangely Southwest	Colorado	Red Wash	Utah	Red Wash	Utah	Red Wash	Utah
Horseshoe Bend	Utah	Lower Horse Draw	Colorado	Lower Horse Draw	Colorado	Natural Buttes	Utah	Horse Shoe Bend	Utah	Natural Buttes	Utah
Blue Bell	Utah	Park Mountain	Colorado	Park Mountain	Colorado	Uteland Butte	Utah	Blue Bell	Utah	Uteland Butte	Utah
Altamont	Utah	Missouri Creek	Colorado	Missouri Creek	Colorado	Eight-Mile Flat	Utah	Brundage Canyon	Utah	Eight-Mile Flat	Utah
Cedar Rim	Utah	White Face Butte	Colorado	White Face Butte	Colorado	Wilkin Ridge	Utah			Wilkin Ridge	Utah
		Baxter Pass	Colorado	Baxter Pass	Colorado	Petes Wash	Utah			Petes Wash	Utah
		Bar X	Colorado	Bar X	Colorado	Castlegate	Utah				
		Harley Dome	Utah	Harley Dome	Utah	Clear Creek	Utah				
		Sieber Nose	Utah	Sieber Nose	Utah						
		Sage	Utah	Sage	Utah						
		Gravel Pile	Utah	Gravel Pile	Utah						
		Cedar Springs	Utah	Cedar Springs	Utah						
		Greater Cisco	Utah	Greater Cisco	Utah						
		Feron	Utah	Flat Canyon Creek	Utah						

Sources: Chidsey et al. 2005; UDOGM 2012a; Wray et al. 2002.

Uranium has been mined in the past in Grand County, but there are no active uranium mines at present. The Uinta Basin has a large oil shale resource and recently oil shale mining has been proposed (Enefit 2011). Other mineral resources in Region II include oil shale, gilsonite, oil sands, gypsum, salt, bentonite, geothermal, cement aggregate (sand, gravel, crushed stone) and clay (USGS 2011; UGS 1983).

3.2.5.3 Region III

Physiography and Geology

All of Region III is within the Great Basin section of the Basin and Range province (**Figure 3.2-11**) (Fenneman 1928).

In Region III, the alternative 2-mile transmission line corridors cross primarily unconsolidated deposits of alluvium, alluvial fan, pediment, and sand dune (Hintze and Davis 2002; Hintze et al. 2003; Steven et al. 1990; Rowley et al. 2006). In the northern portion of Region III, the bedrock crossed includes the Flagstaff and Little Drum Formations. South of Enterprise, Utah, there are Tertiary volcanic and sedimentary rocks and folded Mesozoic and Paleozoic rocks in the western portions of Washington County (Biek et al. 2009). Paleozoic rocks are represented by the Permian Kaibab Formation, which is largely composed of limestone. Mesozoic rocks include the Cretaceous-Tertiary Grapevine Wash Formation, Cretaceous Iron Springs Formation, and the following Jurassic-age rock units: Temple Gap Formation, the Navajo Sandstone, and Kayenta Formation. The Jurassic and Cretaceous rocks are largely composed of sandstones, siltstones, and mudstones with occasional gypsum beds. Triassic-aged rocks are the Moenave and Moenkopi Formations that largely are made up of sandstone, siltstone, mudstone, with minor limestone and gypsum. The Tertiary volcanic rocks include ash flow tuffs such as the Oligocene Leach Canyon Formation and Miocene-Pliocene Rencher Formation. Undivided lava flows also comprise the Tertiary volcanic rocks. Tertiary sedimentary deposits consist of the Paleocene-Eocene Claron Formation and Miocene and Pliocene basin fill. In the Beaver Dam Valley in the extreme southwest corner of Washington County, Utah, there are valley fill alluvial deposits (Biek et al. 2009).

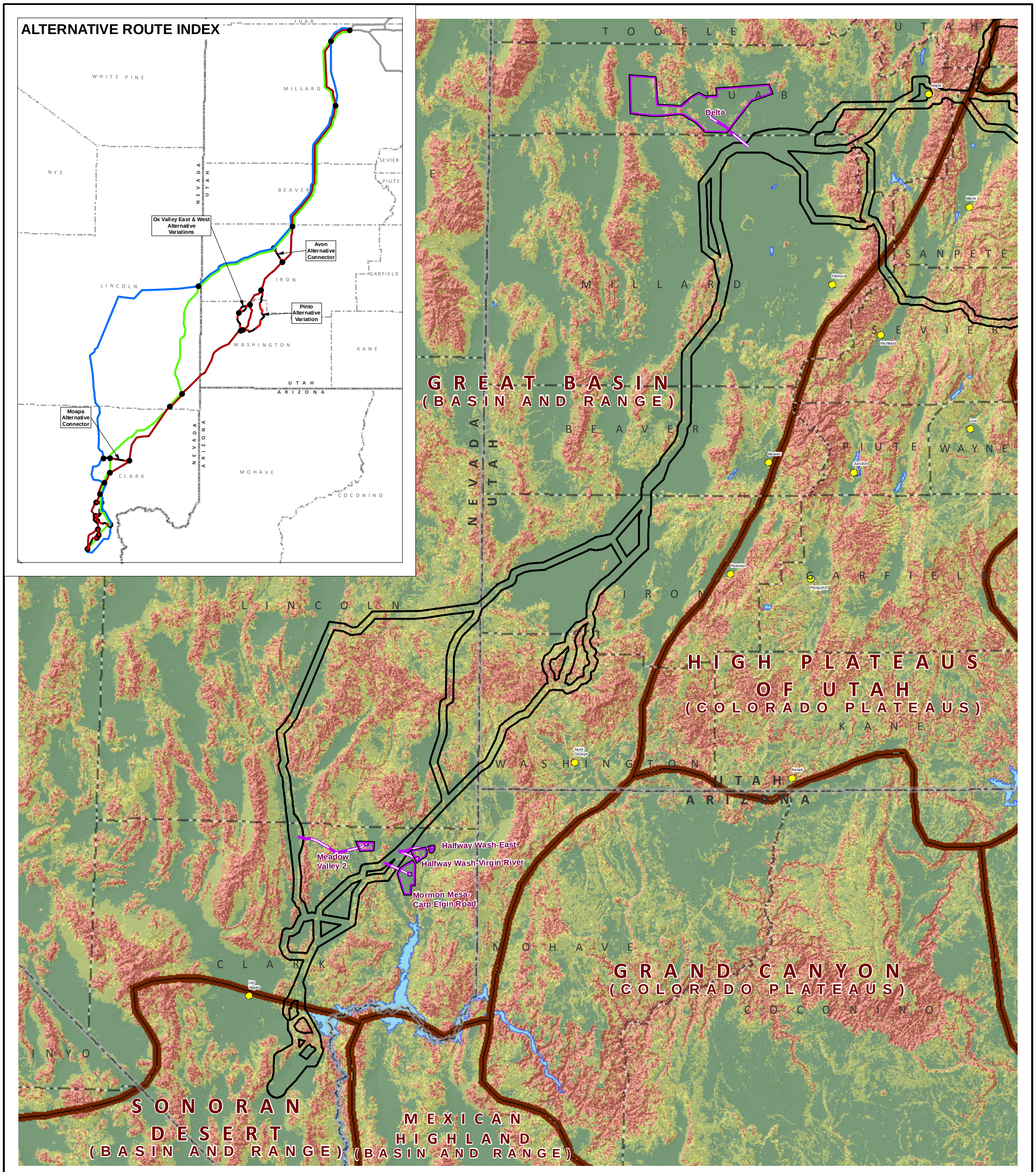
Alternative 2-mile transmission line corridors in southeastern Lincoln County, Nevada primarily cross volcanic rocks of the Clover Mountains caldera complex (Tschanz and Pampeyan 1970). After crossing mountain ranges, the 2-mile transmission line corridors drop down into valley areas covered with alluvium, alluvial fan, and playa deposits and cross occasional outcrops of Tertiary volcanic and Paleozoic rocks. In northeastern Clark County, Nevada, the 2-mile transmission line corridors cross mainly alluvial deposits, but also limited outcrops of Precambrian, Paleozoic, Triassic, and Tertiary rocks (Stewart and Carlson 1978; Tschanz and Pampeyan 1970; Longwell et al. 1965).

In Region III, Paleozoic rocks include Cambrian Prospect Mountain Quartzite, Pioche shale, and Nopa Formation, undivided Cambrian to Devonian sedimentary rocks, Pennsylvanian-Permian Bird Spring Formation, and Permian Coconino Sandstone and Kaibab Limestone. Triassic rocks include the Chinle, Moenkopi, and Thaynes Formations. The Tertiary Horse Spring Formation is found in outcrops northeast of Las Vegas, Nevada.

Geological Hazards

Seismic Hazards

Region III has less earthquake activity than Region II since the proposed alternatives are located to the west of the Utah hingeline area (USGS 2009b). In the Utah portion of Region III, there are several potentially active faults located near or on proposed routes and include the Drum Mountains fault zone west of Delta, Utah, in north central Millard County, and the Escalante Desert fault zone located at the northeast end of the Escalante Desert in northern Iron County and southern Beaver County (USGS and UGS 2006).



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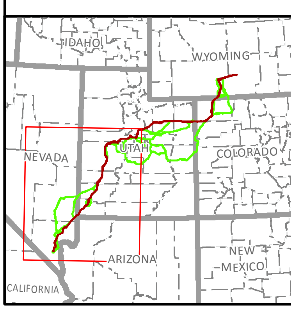

Project Corridor

DEIS Alternative Routes

- Applicant Proposed III/IV- A**
- Alternative III/IV-B*
- Alternative III/IV-C
- Alternative Variation or Connector
- Segment not in this Region
- Physiographic Section (Province)

* Agency Preferred Region III
** Agency Preferred Region IV

- Potential Ground Electrode Siting Area
- Potential Ground Electrode Site
- Potential Ground Electrode Overhead Electrical Line

Topography

- Flat (<5%)
- Rolling (5-15%)
- Steep (15-25%)
- Rugged (>25%)

TRANSWEST EXPRESS TRANSMISSION PROJECT

Figure 3.2-11
Regions III & IV
Physiography and Topography

0 10 20 40 Miles
0 10 20 40 km
1:2,500,000

N

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In the Nevada portion of Region III the potentially active California Wash fault is located about five miles west of Moapa in northern Clark County (Anderson 1999a). No other potentially active faults have been identified in the Region III study area; however, the south end of Delamar Valley in southern Lincoln County contains fissures of uncertain origin (Swadley 1995). These fissures, present in the Delamar and Dry Lake valleys, are not caused by groundwater withdrawal and are thought to be tectonic in origin, but are not thought to be active in the southern portions of the Delamar Valley. Active fissures may be present in the northern Dry Lake Valley, but the alternative 2-mile transmission line corridors do not cross them.

Ground motion hazard mapping indicates that there is a generally low potential for ground motion to cause serious damage from a maximum earthquake that could be predicted for the area (**Figure 3.2-1**). Alternative III-C crosses an area of slightly increased risk of ground motion, similar to the Wasatch Plateau area.

Landslides

The routes in Region III primarily cross areas of very low landslide susceptibility (Giraud et al. 2007). However, portions of the analysis area in Washington County cross areas of low to moderate landslide risk in the Bull Valley Mountains and north flank of the Beaver Dam Mountains.

Subsidence

Alternative 2-mile transmission line corridors in the Utah portion of Region III generally cross valley deposits and the potential for karst development is low. Areas within Washington County, Utah may be underlain by carbonate rocks, but no subsidence or karst has been documented (Biek et al. 2009). In the Escalante Desert in Western Iron County, there is subsidence risk associated with the withdrawal of groundwater. Investigations by the UGS (Lund et al. 2005) have shown that the ground surface in areas of the Escalante Desert has subsided as much as four feet in an area centered around Beryl Junction, Utah. In addition, ground fissures have also developed in the vicinity of Beryl Junction. Reportedly the subsidence in the Escalante Desert has not resulted in damage to surface structures or utilities (Hansen 2008).

In Nevada, Region III includes locations underlain by carbonate or evaporite rocks, but no associated subsidence or karst has been identified (National Atlas 2011). No subsidence areas due to groundwater withdrawal have been identified in the valleys in the Nevada portion of Region III.

Paleontological Resources

Three high-potential fossil-bearing formations are found within the analysis area of Region III. **Table 3.2-6** lists the formations in order of relative age and provides the PFYC ratings for the formations or geologic units. **Figure 3.2-12** shows the PFYC ratings crossed in Region III. Alternative 2-mile transmission line corridors may cross old shorelines left by fluctuations of Lake Bonneville levels during the Pleistocene (1.8 million to 10,000 years ago). Although sand and gravel deposits associated with old lake shorelines may have fossil resources, the shoreline deposits have a PFYC ranking of 2 (BLM 2008c).

Table 3.2-6 Potential Fossil-bearing Formations and PFYC Classifications in Region III

Formation/Rock Unit	Period/Epoch	PFYC Rank
Lake Bonneville Shoreline Deposits	Pleistocene	2
Muddy Creek Formation	Miocene	3a
Flagstaff Formation	Paleocene	5
Claron Formation	Paleocene	5
Cedar Mountain	Lower Cretaceous	5

Table 3.2-6 Potential Fossil-bearing Formations and PFYC Classifications in Region III

Formation/Rock Unit	Period/Epoch	PFYC Rank
Carmel Formation	Jurassic	3
Navajo Sandstone	Jurassic	3
Kayenta Formation	Jurassic	5
Moenave	Jurassic-Triassic	5
Chinle	Triassic	3
Moenkopi	Triassic	3
Kaibab	Permian	3
Toroweap	Permian	3
Big Horse Limestone Member of the Orr Formation	Cambrian	3
Pioche Shale	Cambrian	Not determined

Sources: Biek et al. 2009; Hintze and Palmer 1976; USDOE and USDOI 2008.

The Cambrian-aged Pioche shale contains numerous fossil localities that have assemblages of fossil trilobites, arthropods that lived during the Paleozoic Era. The BLM has established the Oak Springs Summit Trilobite Area, located north of SH-93, about 12 miles west of Caliente, Nevada (BLM 2012c). Oak Springs Summit Trilobite Area has fossils of six types of trilobites in the Pioche Shale exposed in a gravel pit. The trilobites belong to the *Olenellidae* family and have a shell like a horseshoe crab, jointed legs, and compound eyes. These fossils are the remains of animals that lived in a shallow sea 500 to 524 million years ago. The trilobite area is within the Alternative III-C 2-mile transmission line corridor.

Mineral Resources

Important mineral resources consist of aggregate (sand, gravel, crushed stone), cement, gypsum, lime, perlite, geothermal, precious and base metals, and iron (Davis 2011; Doelling and Tooker 1983; Hess and Davis 2010; USGS 2011; UGS 1983) (**Figure 3.2-13**).The alternative 2-mile transmission line corridors cross sand and gravel mining areas along Interstate 15 in northeastern Clark County, Nevada. Although oil and gas are not yet as important as some mineral resources, there has been recent interest in oil and gas leasing. There are no coal resources in the Nevada portion of Region III (USGS and Nevada Bureau of Mines and Geology 1964). In Utah, the Applicant Proposed 2-mile transmission line corridor crosses an area underlain by coal resources of the Harmony Coal Field in northern Washington County (Tabet and Wakefield 2006). However, the coal resource potential of the Harmony Coal Field has been described as “insignificant” (Kirschbaum and Biewick 2000).

In Lincoln County, the 2-mile transmission line corridor for Alternative III-C crosses the historic mining districts of Acoma, Little Mountain, and Delamar in southeast Lincoln County, Nevada (BLM 2004). Perlite, a volcanic glass with numerous industrial applications, was mined in the Acoma District east of Caliente, Nevada (Tschanz and Pampeyan 1970). The Little Mountain District, also east of Caliente, was prospected for copper, but no commercial production was recorded. The main commodities of the Delamar District, southwest of Caliente, were gold and silver, but there were also prospects of copper and manganese. Most of the mining occurred at these districts in the first half of the 20th Century, but there is no active mining at present (Davis 2011). The only active major mine near the Alternatives III-C and III-D corridor in Lincoln County is the Tenacity perlite mine and mill, located south of SH 93 about 20 miles west of Caliente, Nevada.

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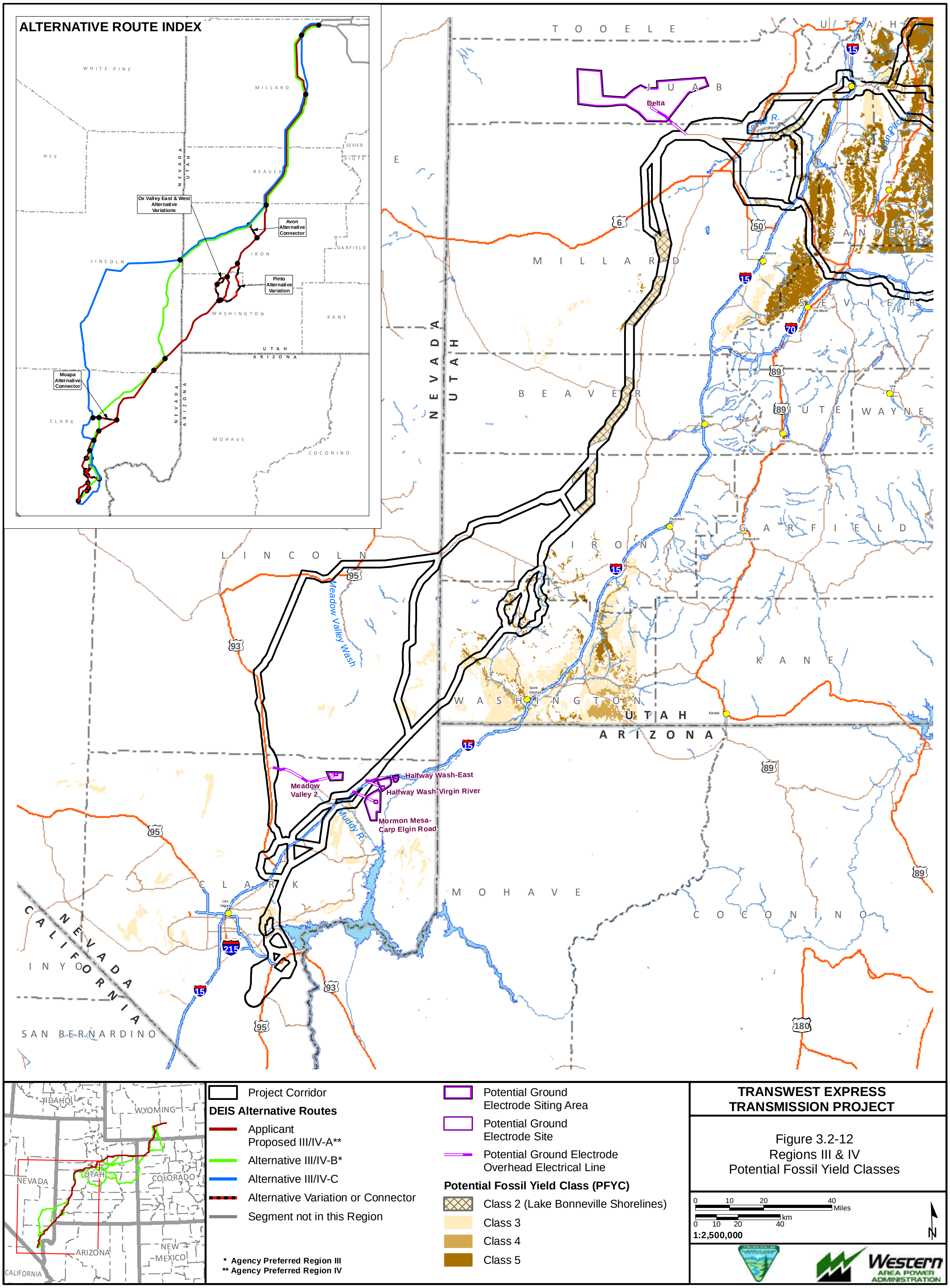

Figure 3.2-12
Regions III & IV
Potential Fossil Yield Classes

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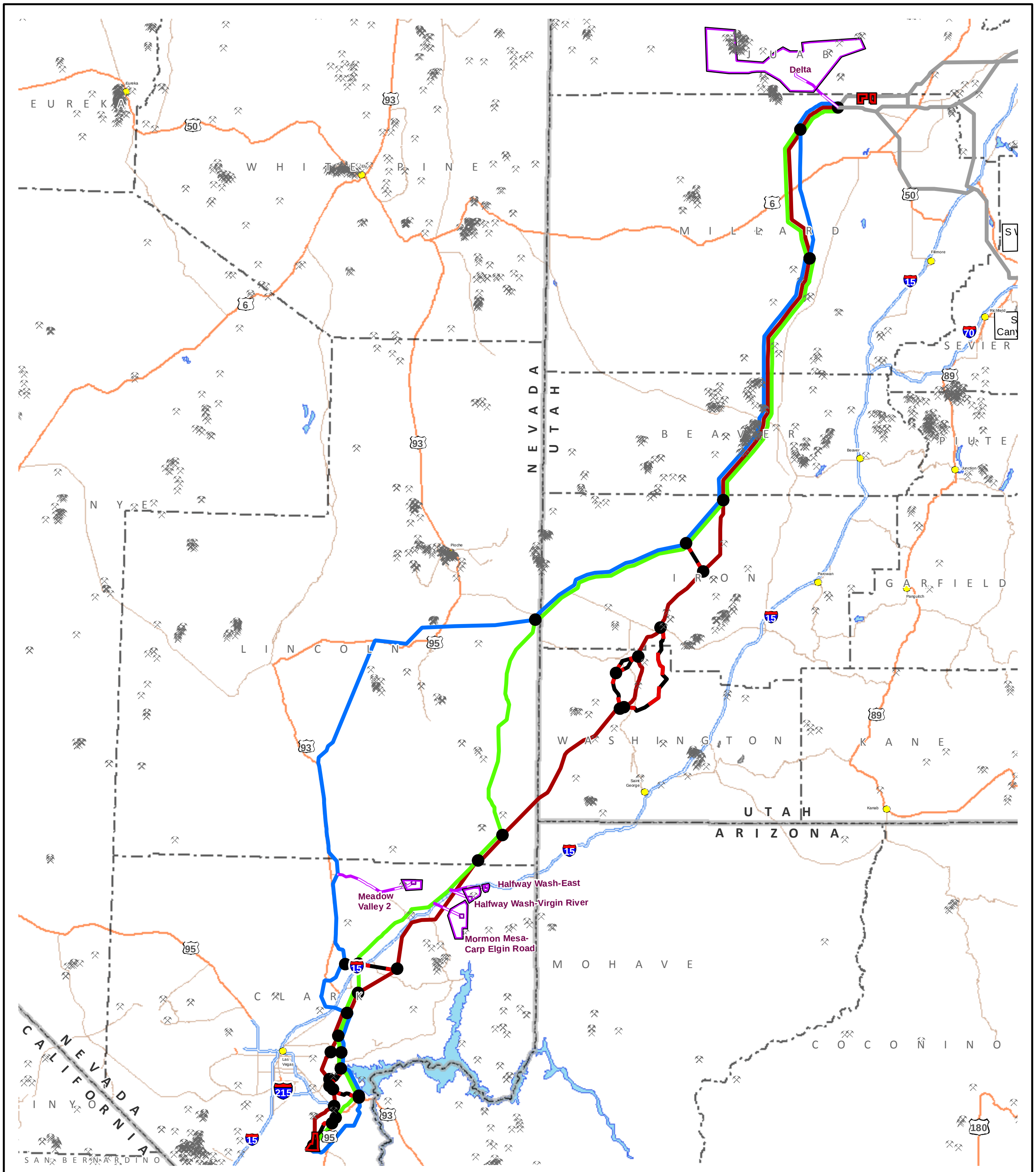

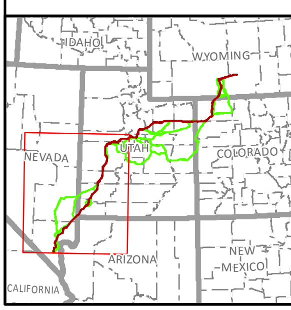

Terminal Siting Area
Node
DEIS Alternative Routes
Applicant Proposed III/IV-A**
Alternative III/IV-B*
Alternative III/IV-C
Alternative Variation or Connector
Segment not in this Region

* Agency Preferred Region III
** Agency Preferred Region IV

Potential Ground Electrode Siting Area
Potential Ground Electrode Site
Potential Ground Electrode Overhead Electrical Line
Mines - Past and Present Metals Production

TRANSWEST EXPRESS TRANSMISSION PROJECT

Figure 3.2-13
Regions III and IV
Mining and Mineral Extraction

0 10 20 40 Miles
0 10 20 40 km
1:2,250,000

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The 2-mile transmission line corridor for Alternative III-B also crosses the Acoma, Vigo, and Gourd Springs mining districts in southeast Lincoln County (Tingley 1998). Very little if any mining took place in the Vigo District, which extends from the southern Clover Mountains to the south end of the Tule Springs Hills (Tingley 1984). A very small quantity of manganese was reported to have been mined in 1926, but the exact location of the prospect is not known. Other potential mineral commodities include gypsum and barium. The Gourd Springs District is located on the east side of the East Mormon Mountains. A small amount (60 tons) of manganese was reported to have been mined from a prospect in the area, but the location could not be found (Tingley 1984).

In Clark County, Nevada high quality limestone and dolomite are mined and processed in the Apex Mining District (Tingley 1998) at the Apex mine and plant operations located about 15 miles northeast of downtown Las Vegas along Interstate 15 (Township 18 South, Range 63 and 64 East). The high-purity limestone from the Crystal Pass Limestone is mined as a constituent in cement (Longwell 1965). Other designated mining districts near or crossed by Region III alternatives in Clark County include the Moapa and Muddy Mountains district. The Moapa District located south of Moapa, Nevada, contains mineral resources of gypsum, magnesite, silica, and uranium (Tingley 1998). Resources of the Muddy Mountains District located east of Interstate 15 and the Virgin River, include borates, bentonite, gypsum, magnesite, and sodium sulfate.

3.2.5.4 Region IV

Physiography and Geology

Region IV is within the Great Basin and Sonoran Desert sections of the Basin and Range province (**Figure 3.2-11**) (Fenneman 1928).

The alternative 2-mile transmission line corridors in Region IV primarily cross alluvial deposits (Stewart and Carlson 1978; Longwell et al. 1965), but also Paleozoic, Triassic and Tertiary sedimentary and volcanic rocks (tuffs and lava flows). Paleozoic rocks include the Pennsylvanian-Permian Bird Spring Formation, Permian Coconino Sandstone, and Kaibab Limestone. Triassic rocks include the Chinle, Moenkopi, and Thaynes formations. Tertiary rocks consist of the Muddy Creek and the Miocene Horse Spring formations and undivided volcanic rocks.

Geological Hazards

Seismicity

The Las Vegas Valley shear zone and the Lake Mead fault system are major east-west strike-slip structural features in Region IV that are believed to have originated as accommodations to extensional forces in the Great Basin (Page et al. 2005; Beard et al. 2010). The Las Vegas shear zone on the north side of the Las Vegas Valley is about 90 miles long and trends northwest to southeast from Mercury, Nevada to the Lake Mead region (**Figure 3.3-14**). Much of the shear zone is buried under basin fill deposits and its geometry has been determined by geophysical studies. Because the shear zone is largely buried under valley fill deposits and has not been documented to cut younger sediments, it is difficult for seismic researchers to determine late Quaternary movement with certainty. The Lake Mead fault system is a generally northeast trending complex of faults that is about 80 miles long from the Lake Mead area to the Virgin Mountains (Beard et al. 2010). Timing of activity along the Lake Mead fault system ranges in age from more than 16 million years ago (Ma) to Quaternary. The Las Vegas shear zone and Lake Mead fault system meet at the north end of the Black Mountains about 6 miles east of Frenchman Mountain, but represent two distinct directions of strike-slip movement. Both the Las Vegas shear zone and Lake Mead fault system are not shown to have potentially active faults in the USGS fold and fault database (USGS and Nevada Bureau of Mines and Geology 2006). However, the Las Vegas shear zone poses concerns as a potential source of very strong earthquakes (DePolo 2008).

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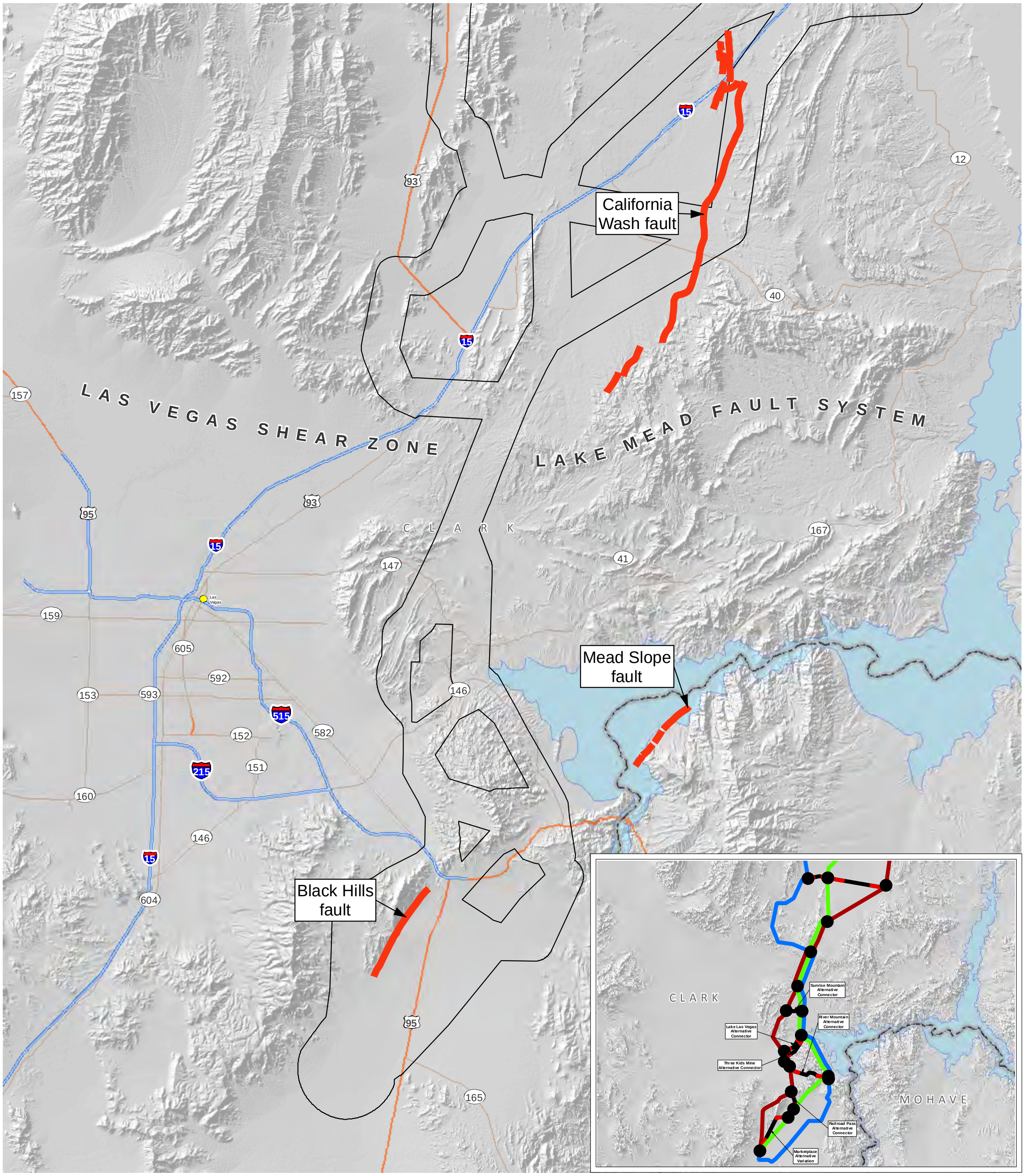

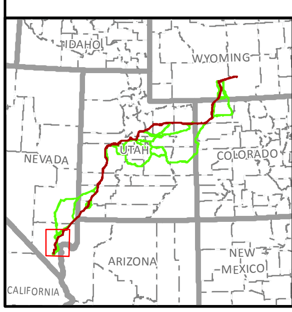

● Node

DEIS Alternative Routes

- Applicant Proposed/ Agency Preferred IV-A
- Alternative II-B
- Alternative II-C
- Alternative Variation or Connector
- Segment not in this Region

Potentially Active Quaternary Fault

TRANSWEST EXPRESS TRANSMISSION PROJECT

Figure 3.2-14
Quaternary Fault Zones in Southern Nevada and Las Vegas and Lake mead Shear Zones

0 2.5 5 10 Miles
0 2.5 5 10 km
1:500,000

N

Western Area Power Administration

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The Las Vegas Valley faults are generally north-south striking east dipping normal faults that are identified by prominent scarps that are present in the central part of the Las Vegas Valley (Page et al. 2005). Towards the southeast end of the valley in the Henderson area, the faults are oriented northwest-southeast, while on the northwestern part of the valley the Eglington fault strikes southwest to northeast. The Eglington fault presents a 100-foot scarp that cuts young valley deposits and is considered to be active, the most recent earthquake event has been estimated to have occurred about 2,000 years ago (dePolo 2008). The fault lengths and displacements indicate the Las Vegas Valley faults are capable of generating earthquakes of moment magnitude (M_w) of 6.3 to 6.9 (M_w is a calculation of magnitude that is a function of rock rigidity, fault area, and slip distance) (Louie 1996). It is likely that the Las Vegas fault system is cut off by the Las Vegas Valley shear zone and strong movement on the Las Vegas shear zone may activate movement on the Las Vegas Valley faults (dePolo 2008).

The Frenchman fault at the west base of Frenchman Mountain is not part of the Las Vegas Valley fault system, but is also potentially capable of posing a seismic hazard to the Las Vegas area (Castor et al. 2000). The Frenchman fault strikes to the north from around Las Vegas Wash to Nellis Air Force Base (Anderson 1999b). All of the Region IV alternative 2-mile transmission line corridors cross the Las Vegas Valley shear zone just northeast of Frenchman Mountain, but the corridors do not cross Las Vegas Valley faults. It is possible that the corridors cross the Frenchman Mountain fault as it curves around the south side of Frenchman Mountain in the vicinity of Las Vegas Wash (Bell and Smith 1980; Castor et al. 2006).

A potentially active fault of concern in Region IV is the Black Hills fault, located on the southeast flank of the Black Hills along the northeast side of the McCullough Range just southwest of Railroad Pass. The Black Hills fault is a southeast dipping normal fault that strikes northeast and forms a series of escarpments at the base of the Black Hills (Anderson 1999c). The fault is considered active because movement appears to have occurred in the last 5,000 years based on the age of the deposits offset by the fault. Recent work by Fossett (2005) indicates that the Black Hills fault may be capable of creating an earthquake of M_w 6.9. The South Terminal Siting Area, the 2-mile transmission line corridors for Alternatives IV-A, IV-B, and the Marketplace Alternative Variation may intersect or are very close to the Black Hills fault zone (a 1,000-foot wide area that extends the length of the fault zone from the base of the Black Hills to 1,000 feet into the valley) (Price and dePolo 2011).

The USGS seismic hazard mapping indicates that in areas crossed by the alternatives in Region IV, ground movement that could be triggered by a maximum credible earthquake is expected to be low; having a PGA of 10 to 15 percent of **g** with a 10 percent probability of exceeding that PGA in 50 years (Petersen et al. 2008).

Landslides

Region IV is an area of low incidence and susceptibility to landslides (Radbruch-Hall et al. 1982).

Subsidence

Subsidence due to groundwater withdrawal has long been recognized in the Las Vegas Valley (Bell et al. 2002). Since 1935, total subsidence in the valley has been approximately 5 feet. Accompanying the subsidence has been the development of ground fissures. None of the alternative 2-mile transmission line corridors cross the Las Vegas Valley or any of the subsidence areas.

Paleontological Resources

Region IV does not have formations with high fossil potential. Two medium potential formations are listed in **Table 3.2-7**. Other sedimentary rock units, mainly the Paleozoic formations listed above, may contain fossils, but also have low PFYC ratings (2 or less) (USDOE and USDOI 2008). **Figure 3.2-12** shows the PFYC ratings crossed in Region IV.

Table 3.2-7 Potential Fossil-bearing Formations and PFYC Classifications in Region IV

Formation/Rock Unit	Period Epoch	PFYC Rank
Muddy Creek Formation	Pliocene	3
Panaca Formation	Miocene-Pliocene	ND
Horse Spring Formation	Lower Miocene	3[1]
Moenkopi Formation	Triassic	3
Pakoon Limestone	Permian	ND
Tippipah Limestone	Pennsylvanian	ND
Blue Point Limestone	Mississippian	ND
Pioche Shale	Cambrian	ND

[1] PFYC based on description in BLM (2004).

Sources: BLM 2012c, 2004; Gordon 1968; Longwell 1928; McNair 1951; USDOE and USDOI 2008.

Mineral Resources

Minerals mined in the Las Vegas area (Region IV) include aggregate (sand and gravel), limestone, dimension stone, and gypsum (Davis 2011; Hess and Davis 2010; USGS 2011). The alternative 2-mile transmission line corridors cross sand and gravel and gypsum mining areas east of Las Vegas, Nevada. Coal is found in isolated localities in several counties in Nevada, but there are no commercially mineable coal seams in the state (USGS and Nevada Bureau of Mines and Geology 1964). Although a number of test wells for oil and gas have been drilled in Lincoln and Clark Counties, no commercial oil and gas production has been found (Garside and Hess 2007).

In the Muddy Mountains District, gypsum is mined at the PABCO mine in Township 20 South, Range 64 East. The gypsum has been mined at this location since 1959 (Castor et al. 2000). The gypsum is over 100-feet thick in places with nominal overburden. Production in 2010 was 682,000 tons (Driesner and Coyner 2011). The 2-mile transmission line corridor that includes the Agency Preferred Alternative and Alternatives IV-A, IV-B, and IV-C may cross or encroach upon the PABCO mine area.

In the Las Vegas Mining District, which includes Frenchman Mountain and areas northeast of Henderson, Nevada to Lake Mead (Tingley 1998), manganese was formerly mined in the region at the Three Kids Mine located on the south side of Lake Mead Drive, just northeast of Henderson, Nevada in Section 35, Township 21 South, Range 63 East (Croft 2012, Bell and Smith 1980). Mining was conducted episodically from 1917 to 1961 from manganese-rich deposits in the Muddy Creek Formation or from volcanic rocks. About 2.25 million tons of manganese ore was extracted from the mine (Longwell 1965). Since the early 1960s, the mine was idle and the mill was dismantled, but the Army Defense Logistic Agency continued to maintain stockpiles of processed material until the end of 2003. One of the former mine pits was even used as a solid waste landfill. The site is slated to become a redevelopment area after site characterization and remediation is complete (Croft 2012). The Three Kids Mine Alternative Connector crosses the Three Kids Mine site. Gypsum has also been mined in the Las Vegas district, but other potential mineral resources include limestone, sand and gravel, silica, lithium, and precious and base metals (Castor et al. 2000).

Another mining district in the Las Vegas area crossed by project alternatives is the Alunite District. The district is located southwest of Railroad Pass in the Black Hills and the commodities of interest historically included gold, tungsten, and alunite (a mineral that is mined for alum and potash) (Tingley 1998). There has been no commercial production of these commodities from the district, but sand and gravel are currently mined at pits south of Railroad Pass (Hess and Davis 2010). Portions of the Southern Terminal

Siting Area, Southern Terminal Alternative, the 2-mile transmission line corridors for Alternatives IV-A, IV-B, IV-C, the Railroad Pass Alternative Connector, and the Marketplace Alternative Variation may be within the Alunite District.

3.2.6 Impacts to Geological, Paleontological, and Mineral Resources

The impact analysis area for geologic, mineral, and paleontological resources consists of the proposed and alternative 2-mile transmission line corridors. Analysis was based on review of publicly available government documents and published literature, as well as comments from scoping.

Relevant scoping issues, management concerns, and impact concerns are listed in **Table 3.2-8**.

Table 3.2-8 Relevant Analysis Considerations for Geological, Mineral, and Paleontological Resources

Resource Topic	Analysis Considerations and Relevant Assumptions
Geologic Hazards	Evaluate risk to the proposed project of geologic hazards that include seismicity, landslides, and subsidence due to karst, groundwater withdrawal, or underground mining. Major assumptions in the analysis of the risk to the proposed project because of geological hazards include the following: • The location of active faults is based on information available from USGS (2006). Ground motion estimates are based on recent updates of the USGS seismic hazard mapping by the USGS (Petersen et al 2008). There are numerous Quaternary faults in the project area, which may rupture at any time, however, only those faults with movement in the last 15,000 years are considered to be active as determined by the USGS (2006). • Landslide risk information is based on landslide maps, landslide incident and susceptibility areas, and USGS publications. • Subsidence risk is due to groundwater withdrawal in the Escalante Desert where it has been documented (Lund et al. 2009). There is also subsidence risk over abandoned coal mines and potential karst topography in areas underlain by the North Horn Formation.
Mineral Resources	Analyze the proposed corridor and alternatives with regard to potential interference with existing mineral extraction operations, reduced access to underlying minerals, and interference with future mineral extraction operations. A major assumption used in the analysis of potential impacts to mineral resources is that mineral entry can take precedence over other land uses and that granting of a utility ROW does not overrule mineral owners' right to develop and extract minerals.
Paleontological Resources	Major issues regarding paleontological resources are loss of important fossils because of the following activities or conditions: • Ground disturbing activities such as clearing, grading, and foundation excavation. • Operational and maintenance activities that would require disturbance of previously unaffected areas within the established ROW. • Increased access resulting in vandalism or unauthorized collection. Major assumptions in the analysis of risk to paleontological resources include the following: Areas underlain by medium to high fossil potential based on the PFYC system for valuable fossil resources were defined on the basis of literature review with heavy reliance on USDOE and USDOI (2008, Appendix N). No field surveys were conducted.

Impacts would occur if the following conditions were to result from the construction, operation, and decommissioning of the proposed facilities:

- An impact from geologic hazards would occur if seismicity, landslides, or subsidence were to result in damage to facilities or interruption of service.
- Landslides could also occur as a result of instability from ground disturbance during construction.
- Impacts to mineral resources would occur if mineral resources of economic value are lost or made inaccessible for future use.
- An impact to fossil resources would result if project activities cause the loss or damage to scientifically important paleontological resources.

3.2.6.1 Impacts from Terminal Construction and Operation

Northern Terminal

There are no identified geologic hazards of concern at the Northern Terminal Siting Area.

The Northern Terminal Siting Area encompasses a geologic structure called the Grenville Dome, an elongate east-west anticline about 5 miles long and 2-3 miles wide. Although several oil and gas tests have been drilled on the structure, no commercial production has been established (Wyoming Oil and Gas Conservation Commission [WOGCC] 2011). Coal may be present in the underlying bedrock, but the potential for mineable resources is low (BLM 2008b). There are no gravel pits within the siting area (WDEQ 2011).

The Northern Terminal Siting Area is underlain by bedrock that has the potential to contain fossils and include the Steele Shale, Niobrara Formation, Frontier Formation, Mowry Shale. These units have PFYC ratings ranging from 3 to 5 (**Table 3.2-2**), indicating the potential for direct and indirect impacts to fossil resources. BMPs PAL-1 through PAL-5 and design options TWE-4,TWE-38, and TWE-39 provide for protection of paleontological resources ranging from pre-construction surveys and documentation of resources, re-routing or avoidance, recovery if avoidance is not possible, and proper documentation and curation of recovered fossils, all of which would be detailed in a Paleontological Resources Management and Mitigation Plan.

Terminal decommissioning activities likely would occur in previously disturbed areas; therefore, no impacts to paleontological resources would be anticipated. If new disturbance is expected, then the application of appropriate BMPs would be required for protect potential fossil resources. No impacts to project facilities from geological hazards or mineral resources would be expected.

Southern Terminal

The Southern Terminal Siting Area is located near the Black Hills fault zone, which may be active. As discussed in Section 3.2.5.4, the Black Hills fault may be capable of generating earthquakes of up to M_w 6.9. Earthquakes of this magnitude have the potential to generate strong ground motion that could damage surface structures. Expected ground motions in any given area are dependent on several factors including distance from the source, local geology, and depth to shallow water. As presented in Section 3.2.5.4, ground motions that might be experienced in southern Nevada could range from 10 to 15 percent of **g** (Petersen et al. 2008). Magnitude is a measure of the energy released from the source earthquake, but intensity is a measure of shaking and associated effects on people and structures (USGS 2010). **Table 3.2-9** compares peak ground acceleration as a percent of **g** to intensity as defined on the Modified Mercalli Intensity Scale. From the table it can be seen that ground motions of 10 to 20 percent of **g** would damage poorly built and non-resistant structures, but well designed structures would sustain slight to no damage.

Table 3.2-9 Abridged Modified Mercalli Intensity Scale Compared to Peak Ground Acceleration

Intensity	Definition	PGA – Percent Acceleration Gravity (g)
I	Not felt except by a very few under especially favorable conditions	
II	Felt only by a few persons at rest, especially on upper floors of buildings.	
III	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.	
IV	Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.	1.5 to 2.0
V	Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.	3.0 to 4.0
VI	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.	6.0 to 7.0
VII	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.	10.0 to 15.0
VIII	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.	25.0 to 30.0
IX	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.	50 to 55
X	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.	More than 60
XI	Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.	As above
XII	Total damage. Objects thrown into the air.	As above

Source: Modified from Bolt (1993) and USGS (2010).

It should be noted that electrical transmission system vulnerability to seismic effects depends on which system components are involved. Transmission structures generally survive well in earthquake events since they are composed of lightweight structures at individual locations connected by conductors that have the ability to adjust to the vibrations of ground motion (Rocky Mountain Power 2010). In addition, structures are built to a standard for wind and ice structural loadings and as such exceed earthquake design loads (American Society of Civil Engineers 1991). A ground electrode bed would not be expected to be adversely affected by the expected ground motions. However, transmission structures are at a somewhat greater risk when built on soils prone to liquefaction. Other facilities such as substations and associated equipment such as ceramic insulators do not fare as well unless specific design considerations are built in or are retrofitted to existing facilities (Yokel 1990).

Because the Southern Terminal Siting area is in an area that could be affected by movement on the Black Hills fault, the following mitigation measure is (**GE-1**) is recommended:

GE-1*: In areas with geologic hazards (e.g., ground shaking, liquefaction, landslides, subsidence from karst, groundwater withdrawal, underground mining, historic mining) and active mining; placement of project structures and other project related disturbance would be avoided to the extent practical. Where avoidance is not possible a site specific geotechnical investigation and engineering design would be implemented during construction and operation of the Project. Depending on the type of potential geologic hazards, the designs may vary and should address specific needs for enhanced structural supports. Site-specific assessment of geologic hazards shall include review of available information concerning areas of mapped hazards and consultation with appropriate governmental agency (USFS, BLM, UGS, USGS) personnel who are knowledgeable about the hazards. Assessment also shall include, if necessary, field surveys and gathering of geotechnical information to determine what engineering design methods would mitigate or lessen potential risks. If active mines cannot be avoided, applicant will conduct similar due diligence in regard to hazards from underground and historic mining to ensure that project facilities will not hinder access to mineral resources or create dangers to mining activities.*

Effectiveness: The mitigation measure would reduce impacts from geologic hazards by incorporating design standards to provide damage protection or by avoidance to lessen risk. The mitigation would also reduce impacts to reduced access to mineral resources.

In addition to the protection measures identified above, some BLM field offices may have stipulations concerning land use restrictions in high landslide incidence areas (**Appendix C**).

As discussed in Section 3.2.5.4, although there is potential for gold, tungsten, and alunite in the Alunite District, those commodities were never commercially mined. The Southern Terminal Siting Area would not interfere with the sand and gravel pits just south of Railroad Pass.

Southern Terminal Alternate

Potential impacts with regard to geologic hazards, paleontological resources, and mineral resources for the Southern Terminal Alternate would be the same as the Southern Terminal.

Southern Terminal near IPP (Design Option 2)

Two fault zones cross the Design Option 2 Delta Ground Electrode Bed Area: the Drum Mountains fault zone and Crater Bench faults (Black et al. 1999a; Black et al. 1999b). The Drum Mountains fault zone is a complex of east- and west-dipping normal faults east of the Drum Mountains. Paleoseismic studies indicate that movement has cut young deposits so that movement may have occurred less than 15,000 years ago, making these faults potentially active. The Crater Bench faults are northeast striking faults east of the Drum Mountains fault zone. The faults also cut deposits younger than Lake Bonneville deposits and therefore may be potentially active. The fault zones described can be easily avoided and the ground bed electrode site can be located away from the fault zones and stay within the boundary of the Delta Ground Electrode Area. Implementation of measure **GE-1** would reduce or eliminate potential impacts with regard to active faults.

The Southern Terminal for Design Option 2 is located on federal minerals that are leased for geothermal exploration (see Section 3.14, Land Use, and **Figure 3.14-18**). The Delta Ground Electrode Bed Area also contains leased geothermal areas and a Known Geothermal Resource Area (KGRA). This situation may lead to potential conflicts with geothermal exploration and development. The substation at the terminal site would have to be located in such a manner to not interfere with geothermal exploration or development. The associated ground electrode bed for Design Option 2 can be located according to siting criteria for ground electrode beds as described in Section 4.2.3 of the PDTR (**Appendix D**) such that the electrode bed would not interfere with geothermal exploration or future geothermal facilities on nearby leased and lands designated as a KGRA.

Design Option 3 – Phased Build Out

Impacts from development of this design option would be the same as those discussed throughout Section 3.2.6.1, Impacts from Terminal Construction and Operation and Section 3.2.6.2, Impacts Common to All Alternative Routes.

The Southern Terminal Siting Area is not underlain by bedrock that has the potential to contain important fossils. The area is underlain by Tertiary volcanic rock and valley fill alluvium (Longwell et al. 1965), both of which have a low potential to contain fossils.

Terminal decommissioning activities likely would occur in previously disturbed areas; therefore, no impacts to paleontological resources would be anticipated. If new disturbance is expected, then the application of appropriate BMPs would be required to protect potential fossil resources. No impacts to project facilities from geological hazards or mineral resources would be expected.

3.2.6.2 Impacts Common to All Alternative Routes and Associated Components

Construction Impacts

Direct impacts of geological hazards during construction would be the potential for grading and excavation to undercut slopes causing instability of slopes and endangering construction crews. BMP **SOIL-2** limits the creation of excessive slopes during excavation and requires site-specific, specialized construction techniques in areas of steep slopes.

Indirect impacts may result from changes in slope and grade that may increase runoff and erosion. There is a potential for seismically induced ground instability that may be further enhanced by undercutting of slopes. Ground motion from a strong earthquake has the potential to initiate movement of unstable earth, although the actual frequency of earthquake-induced landslide occurrence in Utah is not certain (Christenson 2004). Lessening the potential impact of seismically induced landslides would involve implementation of mitigation measure **GE-1**.

A direct impact to mineral resources would occur if construction activities were to prevent access to mineral resources. Any mineral access issues would occur during active construction and amount to road closures or other access restrictions while construction is conducted in a given area. However, other impacts could occur such as land use conflicts and set back limitations that might occur in densely spaced oil and gas field developments. TWE has committed to site the ROW to avoid wellheads and associated facilities at wellheads, and would implement an additional 250-foot avoidance buffer during final centerline siting (TWE 2012). There are additional restrictions described in Appendix C regarding transmission line location and mineral operations.

Conclusion: The proposed project is not expected to preclude or restrict access to minerals resources.

Direct impacts to or destruction of fossils may occur from facility construction activities conducted through medium to high potential fossil beds. Indirect impacts during construction would include erosion of fossil beds due to slope re-grading and vegetation clearing or the unauthorized collection of scientifically important fossils by construction workers or the public due to increased access to fossil localities along the ROW.

BMPs PAL-1 through PAL-5 and design options TWE-4, TWE-38, and TWE-39 provide for protection of paleontological resources ranging from pre-construction surveys and documentation of resources, re-routing or avoidance, recovery if avoidance is not possible, and proper documentation and curation of recovered fossils. These measures would provide a process to protect the resources and potentially add to scientific knowledge. Such measures are highly effective in reducing loss or destruction of the resource. In addition to the protection measures cited above, some BLM field offices have specific protection measures or stipulations for the protection of specific formations or PFYC classes (**Appendix C**).

Conclusion: Project construction would not be expected to result in the loss or damage of scientifically important paleontological resources.

Operation Impacts

During operation and maintenance of the proposed facilities, direct impacts due to seismicity would include permanent ground deformation at faults or ground movement that would cause damage to facilities.

Direct impacts from landslides or unstable ground would result in loss of ground support to structures. Electrical transmission lines have reportedly been impacted by ground stability hazards on the Wasatch Plateau in areas associated with the North Horn Formation. Structural failure and relocation of transmission line routes have resulted because of landslides (debris flows) due to anomalous precipitation events (Smith 2011). Also, large debris flows have occurred in the Wasatch Plateau and well documented examples are the Thistle and Manti Landslides (Fleming 1988; Witkind 1986). Both landslides involved millions of cubic feet of earth material and were older slides reactivated by anomalous precipitation and runoff. The Thistle Landslide, which occurred in April 1983 about 8 miles east of Spanish Fork, Utah, was large enough to block Spanish Fork Canyon and dam water upstream of the slide. The Thistle Landslide also took out the Denver Rio Grande railroad and US Highways 6/89, and the town of Thistle was flooded and destroyed by the impoundment of water behind the slide. The Manti Landslide developed on the south rim of Manti Canyon about 6 miles east of Manti, Utah. The landslide was activated in June 1974 during a period of runoff of heavy snowmelt runoff and eventually grew to dimensions of about 2.2 miles long and 0.5 mile wide. In spite of its size, no structures were threatened or damaged.

Any landslide deposits could be rendered unstable with increased precipitation or high levels of moisture, especially during periods of high runoff of periodic heavy snow cover. Impacts from landslides or unstable ground would result in damage to structures and ultimately disruption in service. Implementation of mitigation measure **GE-1** would lower the risk of locating facilities on unstable areas by the use engineering design and appropriate construction practices to lessen potential impacts due to landslides.

Direct impacts due to ground subsidence also would result in the loss of ground support to structures with the potential to damage and disrupt operations. Implementation of mitigation measures **GE-1** would lower the risk of subsidence.

Conclusion: Through implementation of BMPs, design features, and mitigation measures, the risk of damage from seismicity, landslides or subsidence would be substantially reduced.

A potential direct impact during operation would be loss of access to mineral resources and prevention of the mineral owner (including governmental entities) to develop minerals. However, the linear nature of the project would minimize any potential restriction of access to mineral resources.

Indirect effects could occur to mineral industry facilities (such as pipelines and wells) located adjacent to or within the operational ROW due to EMF. Effects from EMF would be dealt with by implementation of BMP **PD-2**, which calls for identification and delineation of existing underground metallic pipelines or well casings in the vicinity of a proposed electricity transmission line project and to design the project to avoid accelerating the corrosion of the pipelines and pumping wells. See Section 3.18, Public Health and Safety for additional information on the effects of EMF.

Conclusion: Project operation would not preclude access or prevent the development of mineral resources.

Indirect impacts may occur to paleontological resources over an extended period of time, because of increased access to medium to high fossil potential formations. The BMPs and design features that protect paleontological resources discussed in construction impacts would lessen the risk of impacts if maintenance activities occur outside of previously disturbed areas. However, the resource would still be at risk through the continuation of natural processes (e.g. erosion) and unauthorized collection.

Conclusion: Project operation would not be expected to result in the loss or damage of scientifically important paleontological resources.

Decommission Impacts

Potential impacts from Project decommissioning to geological hazards and mineral resources are similar to construction impacts, but to a lesser degree. Decommissioning activities would likely occur in previously disturbed areas; therefore no impacts to paleontological resources would be anticipated. If new disturbance is expected, then the application of appropriate BMPs and mitigation measures would be required to protect potential fossil resources similar to construction. Decommissioning may have a positive impact in that the removal of facilities would allow access to mineral resources.

Conclusion: Project decommissioning would not be expected to result in mineral resources of economic value being lost or made inaccessible for future use, or result in the loss or damage to scientifically important paleontological resources.

3.2.6.3 Region I

Project construction, operation, and decommissioning impacts in Region I would be the same as those discussed in Section 3.2.6.2, Impacts Common to All Alternative Routes and Associated Components. **Table 3.2-10** provides a comparison of impacts associated with the alternative routes in Region I after consideration of BMPs, design features, and mitigation measures.

Table 3.2-10 Summary of Region I Alternative Route Impacts

Parameter	Alternative I-A	Alternative I-B	Alternative I-C	Alternative I-D
Seismicity	No active faults; low ground motion potential.	Same as Alternative I-A	Same as Alternative I-A	Same as Alternative I-A
Landslides	Generally low incidence and moderate susceptibility.	Same as Alternative I-A	Same as Alternative I-A	Same as Alternative I-A
Subsidence	Low potential for karst areas.	Same as Alternative I-A	Same as Alternative I-A	Same as Alternative I-A
Mineral Resources	Route crosses 7 oil and gas fields. No active coal mine permit areas are crossed.	Route crosses 12 oil and gas fields. No active coal mine permit areas are crossed.	Route crosses 8 oil and gas fields. No active coal mine permit areas are crossed. Crosses area of abandoned coal mines south of Craig, Colorado.	Route crosses 7 oil and gas fields. No active coal mine permit areas are crossed.
Paleontological Resources	PFYC Class 3: 29 miles Class 4: 2 miles Class 5: 92 miles	PFYC Class 3: 29 miles Class 4:2 miles Class 5: 111 miles	PFYC Class 3: 76 miles Class 4: 2 miles Class 5: 74 miles	PFYC Class 3: 29 miles Class 4: 2 miles Class 5: 123 miles

There are no active faults in Region I and expected ground motions from an earthquake would be low. Seismicity impacts are expected to be minimal for all four alternative routes. Region I has a generally low incidence and moderate susceptibility to landslides. Although many oil and gas fields are crossed, mineral resource access issues would only occur during active construction and consist of road closures or other access problems while construction is conducted in a given area. No alternatives cross proposed coal lease tracts (BLM 1980). The proposed route and alternatives cross medium to high fossil potential formations as listed on **Table 3.2-2**.

Alternative I-A (Applicant Proposed)

Key Parameters Summary

Alternative I-A would not be expected to be impacted by seismicity, landslides, or subsidence that results in damage to facilities or interruption of service. Seven oil and gas fields would be crossed. Approximately 92 miles of PFYC Class 5 formations would be crossed.

Alternative I-B

Key Parameters Summary

Alternative I-B would not be expected to be impacted by seismicity, landslides, or subsidence that result in damage to facilities or interruption of service or result in mineral resources of economic value being lost or made inaccessible for future use. Twelve oil and gas fields would be crossed. Approximately 111 miles of PFYC Class 5 formations would be crossed.

Alternative I-C

Key Parameters Summary

Alternative I-C would not be expected to be impacted by seismicity, landslides, or subsidence that would result in damage to facilities or interruption of service or result in mineral resources of economic value being lost or made inaccessible for future use. Eight oil and gas fields would be crossed. Approximately 74 miles of PFYC Class 5 formations would be crossed. Alternative I-C does not cross the proposed coal lease tracts in the Green River Coal Field as defined by BLM (1980). Corridor segment 190.00 contains historic coal mining areas near Craig, Colorado where subsidence has been documented (Colorado Geological Survey 2011). Implementation of mitigation measure **GE-1** would reduce the risk of impacts of mine subsidence.

Alternative I-D (Agency Preferred)

Key Parameters Summary

Alternative I-D would not be expected to be impacted by seismicity, landslides, or subsidence that result in damage to facilities or interruption of service or result in mineral resources of economic value being lost or made inaccessible for future use. Seven oil and gas fields would be crossed. Approximately 123 miles of PFYC Class 5 formations would be crossed.

Tuttle Easement Micro-siting Options 1, 2, and 3

The geologic formations crossed by the Tuttle Easement micro-siting options 1, 2, and 3 would not differ substantially from Alternative I-D. The micro-siting options would not pose a greater risk to paleontological or mineral resources or increased risk from geologic hazards.

Alternative Connectors in Region I

Table 3.2-11 summarizes impacts and advantages associated with the alternative connectors in Region I.

Table 3.2-11 Summary of Region I Alternative Connector Impacts

Alternative Connector	Analysis	Conclusion
Mexican Flats Alternative Connector	Low geologic hazard risk; one oil and gas field crossed; 5 miles of Class 5 PFYC formations crossed.	There are no apparent unique opportunities or constraints for geologic resources by utilizing this connector.
Baggs Alternative Connector	Low geologic hazard risk; three oil and gas fields crossed; 16 miles of Class 5 PFYC formations crossed.	There are no apparent unique opportunities or constraints for geologic resources by utilizing this connector.
Fivemile Point North Alternative Connector	Low geologic hazard risk; one oil and gas field crossed; 3 miles of Class 5 PFYC formations crossed.	There are no apparent unique opportunities or constraints for geologic resources by utilizing this connector
Fivemile Point South Alternative Connector	Low geologic hazard risk; one oil and gas field crossed; 3 miles of Class 5 PFYC formations crossed.	There are no apparent unique opportunities or constraints for geologic resources by utilizing this connector

Alternative Ground Electrode Systems in Region I

The northern ground electrode system would be necessary within 100 miles of the northern terminal as discussed in Chapter 2.0. Although the location for this system has not been determined, conceptual locations and connections to the alternative routes have been provided in the project POD. The impacts associated with constructing and operating this system are the same as discussed for Alternative I-A. **Table 3.2-12** summarizes impacts associated with the eight combinations of alternative route and location possibilities for the northern ground electrode system.

Table 3.2-12 Summary of Region I Alternative Ground Electrode System Impacts

Ground Electrode System Name	Analysis
Separation Flat – All Alternative Routes	Potential impacts to paleontological resources; bedrock consists of the Battlespring Formation (PFYC 3). No impacts regarding geological hazards or mineral resources.
Separation Creek – All Routes	Potential impacts to paleontological resources; bedrock consists of Fort Union Formation (PFYC 3), Lance Formation (PFYC 5), and Lewis Shale (PFYC 3). No impacts regarding geological hazards or mineral resources.
Eight-Mile Basin – All Routes	Potential impacts to paleontological resources; bedrock consists of Steele Shale (PFYC 3); Niobrara Formation (PFYC 5); and Mesaverde Formation (PFYC 3-5). No impacts regarding geological hazards or mineral resources.
Shell Creek (Alternative I-A)	Potential impacts to paleontological resources; bedrock consists of Green River Formation (PFYC 4-5); Wasatch Formation (PFYC 5), and Washakie Formation (PFYC 5). No impacts regarding geological hazards or mineral resources.
Shell Creek (Alternative I-B)	Impacts would be the same as Shell Creek (Alternative I-A).
Little Snake East (Alternative I-A)	Potential impacts to paleontological resources; bedrock consists of the Wasatch Formation (PFYC 5). No impacts regarding geological hazards or mineral resources.
Little Snake West (Alternative I-A)	Impacts would be same as Little Snake East (Alternative I-A).
Little Snake East (Alternative I-B)	Impacts would be same as Little Snake East (Alternative I-A).

Region I Conclusion

There are no appreciable differences (**Table 3.2-10**) between the Region I alternative corridors in terms of geologic hazards since no active faults are crossed by any of the routes, potential seismic ground motion is low, landslide incidence is low, and there are no ground subsidence hazards. Potential impacts to minerals are similar except that Alternate I-B crosses more oil and gas fields than the other alternatives. Although coal resource areas are crossed, none of the alternatives cross active mining areas. The alternatives are similar regarding potential impacts to paleontological resources in Class 3 and Class 4 formations. Alternative I-D crosses more miles of Class 5 formations than the other alternatives. The alternative connectors are essentially the same except that the Baggs Alternative Connector may pose more impact to paleontological resources since it crosses 16 miles of PFYC rank 5 formations, as compared to 5 miles or less for the others (**Table 3.2-11**). Paleontological resources are the most potentially impacted by the ground electrode systems (**Table 3.2-12**). Except for Separation Flat, the ground electrode systems are essentially the same in that they have the potential to impact PFYC 4 or 5 formations. No impacts due to geological hazards or mineral resources are anticipated for any of the ground electrode systems. None of the areas appear to have oil and gas well densities that would preclude the siting of a ground electrode system.

3.2.6.4 Region II

Project construction, operation, and decommission impacts in Region II would be the same as those discussed in Section 3.2.6.2, Impacts Common to All Alternative Routes and Associated Components. **Table 3.2-13** provides a comparison of impacts associated with the alternative routes in Region II.

<u>Alternative II-A (Applicant Proposed)</u>

The Alternative II-A corridor has potential for impacts from seismically induced ground instability, which would be decreased through implementation of mitigation measure **GE-1**. It also would be subject to increased slope instability where the route crosses the High Plateaus of Utah (**Figure 3.2-8**). The route crosses not only the North Horn Formation with its high degree of susceptibility to landslides, but also other areas of unstable bedrock and surficial materials. Although the presence of North Horn Formation bedrock has been implicated in many slides and incidents of instability, the landslide mapping by the UGS (Elliott and Harty 2010) clearly shows extensive landslide deposits beyond the areas underlain by the North Horn formation. Construction on unstable materials or on dormant landslide deposits could result in instability and present safety hazards and construction delays.

The Alternative II-A corridor would cross the Thistle Landslide area. From where it enters Wasatch County to about 10 miles east of Nephi, Utah the Proposed Route II-A covers large areas of mapped landslides (Elliott and Harty 2010). The landslide material is characterized as up to 10 feet deep and ranges from easily identified discrete landslide deposits to material coalesced from several landslides. This is an extensive area (8 miles of the 2-mile transmission line corridor) of landslide deposits about 7 miles north of Fountain Green, Utah. The implementation of mitigation measure **GE-1** would reduce the impacts of landslides in the Wasatch Plateau. This mitigation measure would be applied in identified landslide and landslide-prone areas associated with the North Horn, Green River, and Duchesne River formations.

The Alternative II-A corridor crosses the south end of the Strawberry fault zone in Wasatch County just east of the Utah-Wasatch county line. The Strawberry fault zone is generally a north-trending 20 mile-long fault zone that bounds the east side of the Strawberry Valley (Black et al. 1999c). The fault is recognized on well developed scarps and evidence indicates that movement has taken place on the fault 3 times in the last 15,000 to 30,000 years. This alternative also crosses the south end of the Nephi Segment of the Wasatch fault zone just north of Nephi, Utah (Black et al. 2004a). Evidence from faulted surficial deposits indicates that movement on the Nephi segment may have occurred as recently as 300 to 1200 years ago. North of Delta, the Proposed Route II-A crosses the Sugarville Area Faults. The short northeast trending faults are about 4 miles north of Sugarville, Utah and cut Pliocene and Holocene sediments with evidence indicating at least two seismic events (Black et al 1999d). The Nephi Fault has been assigned a potential maximum magnitude that ranges from 6.8 to 7.2 (Petersen et al. 2008). The Strawberry Fault has a potential magnitude of 6.92. The Sugarville Faults have not been assigned an expected earthquake magnitude. Implementation and mitigation measure **GE-1** would reduce potential impacts due to potentially active faults.

Table 3.2-13 Summary of Region II Alternative Route Impacts

Parameter	Alternative II-A	Alternative II-B	Alternative II-C	Alternative II-D	Alternative II-E	Alternative II-F
Seismicity	Moderate to high risk for ground deformation and strong ground motion. Crosses 3 active fault zones.	Same as Alternative II-A. Crosses 4 active fault zones.	Same as Alternative II-A. Crosses 5 active fault zones.	Low to moderate risk. Crosses 2 active fault zones.	Same as Alternative II-D.	Same as Alternative II-D.
Landslides	Moderate to high risk for landslide impacts.	Same as Alternative II-A.	Same as Alternative II-A.	Same as Alternative II-A.	Same as Alternative II-A.	Same as Alternative II-A.
Subsidence	Low to moderate risk for ground subsidence. Crosses historic coal mining areas.	Same as Alternative II-A.	Slightly higher risk than Alternatives II-A and II-B since evidence of sinkholes found near the route.	Same as Alternative II-A.	Same as Alternative II-A.	Same as Alternative II-A.
Mineral Resources	6 oil and gas fields crossed. Encroaches on lease by application and proposed coal mining areas at the Deserado Mine. Crosses historic coal mine areas northwest of Deserado Mine.	15 oil and gas fields crossed. In Colorado, Deserado mine permit area crossed. In Utah, Deer Creek Coal Mine permit area crossed. Approximately 15 miles of active mine permit areas crossed.	15 oil and gas fields crossed. In Colorado, Deserado mine permit area crossed. In Utah, the II-C corridor encroaches on the eastern side of the active Emery coal mine.	9 oil and gas fields crossed. In Utah, crosses active and inactive coal mining areas as well as potential coal development areas in the Book Cliffs and Wasatch coal fields. Approximately 5 miles of active mine permit areas crossed. Encroaches on lease by application and proposed coal mining areas at the Deserado Mine. Crosses historic coal mine areas northwest of Deserado Mine.	5 oil and gas fields crossed. Encroaches on lease by application and proposed coal mining areas at the Deserado Mine. Crosses historic coal mine areas northwest of Deserado Mine.	7 oil and gas fields crossed. Encroaches on lease by application and proposed coal mining areas at the Deserado Mine. Crosses historic coal mine areas northwest of Deserado Mine.
Paleontological Resources	PFYC Class 3: 8 miles Class 4: 0 miles Class 5: 120 miles	PFYC Class 3: 116 miles Class 4: 6 miles Class 5: 74 miles	PFYC Class 3: 127 miles Class 4: 6 miles Class 5: 77 miles	PFYC Class 3: 20 miles Class 4; 0 miles Class 5: 129 miles	PFYC Class 3: 9 miles Class 4: 0 miles Class 5: 113 miles	PFYC: Class 3: 8 miles Class 4: 0 miles Class 5: 156 miles

There is not a comprehensive database concerning subsidence and karst hazards regarding the North Horn Formation and Flagstaff Limestone in the Wasatch Plateau or valleys in adjacent areas to the west of the plateau. It is not certain how widespread the phenomenon is because in the reports cited above, the descriptions of sinkholes were incidental to the main subject of the respective reports. Because of this it is not possible to assign a risk to the alternatives; however, since all the routes cross the North Horn formation and Flagstaff Limestone, they are potentially subject to ground subsidence hazard risks, which can include loss of support and subsequent damage to structures and possibly loss of service. The risk of subsidence hazards would be substantially reduced by implementation of mitigation measure **GE-1**.

The Alternative II-A 2-mile transmission line corridor lies just north of the Deserado Mine permit area and may encroach upon lease by application and proposed mining areas (BLM 2011). Also, there are historic coal mines within or adjacent to the corridor northwest of the Deserado Mine in Township 3 North, Range 102 West (Carroll 2006). Implementation of mitigation measure **GE-1** would lower the risk of encountering subsidence from active or historic mining.

Alternative II-A may cross relict shorelines and associated deposits from Lake Bonneville. While these deposits have a PFYC rating of 2, scientifically important fossils have been found in sand and gravel deposits associated with the old shorelines. It is recommended BMPs PAL-1 through PAL-5 and design options TWE-4, TWE-38, and TWE-39 be implemented where the 2-mile transmission line corridor crosses these old shorelines to protect potential fossil resources.

Key Parameters Summary

There is an elevated risk that landslide areas crossed by Alternative II-A might result in damage to facilities or interruption of service during the operation of the Project, which would be a significant impact. Seismicity and subsidence risks would not be expected to result in damage to facilities or interruption of service during the operation of the Project. Six oil and gas fields would be crossed. Approximately 120 miles of PFYC Class 5 formations would be crossed.

<u>Strawberry IRA Micro-siting Options 1, 2, and 3</u>

The geologic formations crossed by the Strawberry IRA micro-siting options 1, 2, and 3 would not differ substantially from Alternative II-A. The micro-siting options would not pose a greater risk to paleontological or mineral resources or increased risk from geologic hazards.

<u>Alternative II-B</u>

Alternative II-B also crosses isolated landslide deposits between Huntington and Mount Pleasant, Utah and landslide deposits north and east of Fountain Green, but the deposits are not quite as extensive as the ones further north crossed by Alternative II-A. The Manti Landslide is less than 30 miles south of Alternative II-B where the alternative crosses the high terrain between Huntington and Mount Pleasant. The alternative also crosses areas of high landslide risk in the Baxter Pass area in western Garfield County, Colorado where the route follows the Baxter Pass Road. Landslides have occurred on steep slopes underlain by sandstones, siltstones, and shales of the Green River and Mesaverde formations (Stover 1985). As discussed in Alternative II-A above, implementation of mitigation measure **GE-1** would lessen potential landslide impacts; however there would remain an elevated risk that a landslide in this area might result in damage to facilities or interruption of service during the operation of the Project.

Alternative II-B crosses the Joes Valley faults about 20 miles northwest of Huntington, Utah. The faults consist of 2 parallel north-south trending fault zones (Black et al. 1999e,f). The easternmost of the fault zones marks the east boundary of the graben (a down-dropped block of crust) that forms the Joes Valley. The second fault zone west of the boundary fault is internal to the graben structure. Both sets of faults zones are believed to have been active within the last 15,000 years and would be considered potentially active. The faults described above have been assigned potential maximum magnitudes that range from 6.6 to 7.5, the largest potential magnitude for the Joes Valley east and mid-valley faults (Black et al. 1999e,f; UGS 2011b). Alternative II-B also crosses the Levan Segment of the Wasatch fault zone and the Sugarville area faults, which are considered to be potentially active. Implementation of mitigation measure **GE-1** would reduce the risk due to potentially active faults.

Alternative II-B crosses the North Horn formation. Its potential for subsidence is discussed in Alternative II-A. Implementation of mitigation measure **GE-1** would decrease the potential risk due to subsidence.

Another subsidence hazard is posed by underground coal mines. Alternative II-B crosses the permit area of the Deer Creek Mine about 10 miles northwest of Huntington, Utah (Townships 16 and 17 South and Ranges 6 and 7 East) (UDOGM 2012b). The mine utilizes the longwall mining method, which controls surface subsidence in comparison to other mining methods (Ismaya 2010). Subsidence has been monitored over mining areas since the early 1980s (Energy West Mining Company 2010). As many as 28 areas were monitored over this period of time, but a number of areas are not actively being monitored because subsidence has occurred to its ultimate extent or little or no subsidence was detected. However, subsidence in some areas has been as much as 17 feet where dual seam mining occurred. In addition to modern mining, there are historic underground mines within the permit area.

The Alternative II-B 2-mile transmission line corridor crosses the southeast portion of the Deserado Mine permit area in northwest Colorado (BLM 2011). Implementation of mitigation measure **GE-1** would reduce or eliminate impacts to crossing an active mine permit area. Sinkholes also have been associated with the North Horn Formation in the Wasatch Plateau. In 1954, mastodon, horse, and bison bones were discovered in a sinkhole in the North Horn formation about 2 miles west of Huntington Reservoir (Gillette and Miller 1999). This sinkhole was reported to be 13 feet deep and was probably instrumental in trapping the animals whose fossilized remains were found in the sinkhole. The sinkhole-fossil locality is only about 5 to 6 miles north of Alternative II-B on the west side of the Wasatch Plateau and about 10 miles east of Mount Pleasant, Utah.

Alternative II-B may cross relict shorelines and associated deposits from Lake Bonneville. While these deposits have a PFYC rating of 2, scientifically important fossils have been found in sand and gravel deposits associated with the old shorelines. Where the 2-mile transmission line corridor crosses these old shorelines, it is recommended that BMPs PAL-1 through PAL-5 and design options TWE-4, TWE-38, and TWE-39 be implemented to protect potential fossil resources.

Key Parameters Summary

There is an elevated risk that landslide areas crossed by Alternative II-B might result in damage to facilities or interruption of service during the operation of the Project. Seismicity and subsidence risks also are present, but would not be expected to result in damage to facilities or interruption of service during the operation of the Project. Fifteen oil and gas fields are crossed that might result in mineral resource access conflicts. Approximately 15 miles of coal mine permit areas are crossed. The Alternative II-B 2-mile transmission line corridor crosses the Deserado Mine permit area in northwest Colorado and also crosses the Deer Creek Coal mine permit area in Utah. Approximately 74 miles of PFYC Class 5 formations are crossed, which have an elevated risk for impacting fossil resources.

<u>Alternative II-C</u>

Between the towns of Emery and Salina, Utah, Alternate II-C roughly follows Interstate 70. Where the 2-mile transmission line corridor is south of the interstate it crosses areas of landslide deposits that can be shallow or deep and include talus, rock-fall, colluvium, and soil creep deposits (Elliott and Harty 2010). The alternative also crosses areas of high landslide risk in the Baxter Pass area in western Garfield County, Colorado where the route follows the Baxter Pass Road. Landslides have occurred on steep slopes underlain by sandstones, siltstones, and shales of the Green River and Mesaverde formations (Stover 1985). Implementation of mitigation measure **GE-1** would lessen the risks of landslides.

The proposed Alternative II-C crosses potentially active faults along the east side of the Pavant Range (Maple Grove, Pavant, and Scipio faults) and northward into the Scipio Valley (Scipio Valley faults) (Black et al. 2004b,c,d,e). These faults trend north-south and all appear to have movement within the last 15,000 years. Further north, The Lynndyl Alternative Connector crosses the Little Valley fault zone where generally north trending faults occur on the east and west sides of the valley (Black et al. 1999g). Offset of valley alluvial deposits indicate movement in the last 15,000 years. Latest evidence indicates that the Pavant, Scipio, Scipio Valley, and Little Valley faults may be part of the same continuous fault zone (UGS 2011b). The faults described above have not been assigned potential maximum magnitudes (Petersen et al. 2008; UGS 2011b). Alternative II-C also crosses the Levan Segment of the Wasatch fault zone and the Sugarville area faults, which are considered to be potentially active. Implementation of mitigation measure **GE-1** would reduce impacts due to potentially active faults.

The Manti Landslide location is less than 30 miles north of Alternative Route II-C where the route follows Interstate Highway 70 between Emery and Salina, Utah. This alternative generally follows the route of a transmission line that was heavily damaged in 1983 due to instability from heavy precipitation and runoff and portions of the line had to be relocated to more stable ground (Smith 2011). Mitigation measure **GE-1** would reduce the risk of damage or interruptions of service; however there would remain an elevated risk that a landslide in this area might result in damage to facilities or interruption of service during the operation of the Project.

Ground subsidence risk also is present in the North Horn formation. The upper part of the North Horn Formation contains limestone that may be subject to dissolution resulting in the development of sinkholes. The Flagstaff Limestone, which lies above and may interfinger with the North Horn formation, also may be subject to dissolution (Bjorkland and Robinson 1968; Lawton et al. 1993). Sinkholes in the southern Scipio Valley have been attributed to groundwater solution of North Horn carbonates and Flagstaff Limestone beneath valley fill deposits. The sinkholes occur on the surface traces of the Scipio Valley faults. Bjorkland and Robinson (1968) postulated that groundwater migrated into fractures in the North Horn and Flagstaff Limestone bedrock and dissolved the carbonate layers. The sinkholes developed as the surface manifestation of the dissolution. The North Horn formation and Flagstaff Limestone exposed on the east side of the Scipio Valley were observed to be heavily fractured with evidence of solution. The sinkholes in the Scipio Valley were described to be up to 25 feet deep, 30 feet wide, and 200 feet long and some may have been interconnected by voids in the subsurface. The sinkholes appear to be just east of the Alternative II-C 2-mile transmission line corridor, but present-day Interstate 15 appears to cross the areas where sinkholes were identified on the geologic map accompanying the USGS report by Bjorkland and Robinson (1968).

Alternative II-C crosses the North Horn formation with its potential for subsidence is discussed in Alternative II-A. Alternative II-C 2-mile transmission line corridor encroaches on the southern and eastern edges of the Emery Deep Coal Mine located in Township 22 South, Range 6 East 4.0 miles south of Emery, Utah (UDOGM 2012b). The mine has been operated intermittently since the 1970s and re-opened in 2005 using the continuous mining method (Consolidation Coal Company 2010; Vanden Berg 2010). Expected subsidence magnitude ranges from 1 to 3.5 feet. Alternative II-C 2-mile transmission line corridor crosses the Deserado Mine permit area in northwest Colorado. Mitigation measure **GE-1** would decrease the potential risk of subsidence due to coal mining.

Alternative II-C may cross relict shorelines and associated deposits from Lake Bonneville. While these deposits have a PFYC rating of 2, scientifically important fossils have been found in sand and gravel deposits associated with the old shorelines. To protect potential fossil resources, it is recommended that BMPs PAL-1 through PAL-5 and design options TWE-4, TWE-38, and TWE-39 be implemented where the 2-mile transmission line corridor crosses these old shorelines.

Key Parameters Summary

There is an elevated risk that landslide areas crossed by Alternative II-C might result in damage to facilities or interruption of service during the operation of the Project. Seismicity and subsidence risks also are present, but would not be expected to result in damage to facilities or interruption of service during the operation of the Project. Fifteen oil and gas fields are crossed that might result in mineral resource access conflicts. Approximately 6 miles of coal mine permit areas are crossed. Additionally, 77 miles of PFYC Class 5 formations are crossed, which have an elevated risk for impacting fossil resources.

<u>Alternative II-D</u>

Alternative II-D crosses areas of mapped landslides and landslide prone areas. The 2-mile transmission line corridor also crosses oil and gas fields and active and inactive underground coal mining areas. The active mine permit areas include the Skyline Mine (located in portions of Townships 12, 13, and 14 South; Range 6 East) and the Horizon Mine (located in Township 13 South; Range 8 East) (UDOGM 2012b). The alternative also crosses the Willow Creek Mine area (located in Townships 12 and 13 South; Ranges 9 and 10 East) which was closed in September 2002 and is undergoing reclamation. Associated with the active mines mentioned above are also areas of historic mining and future potential development areas (BLM 2008d).

The Alternative II-D 2-mile transmission line corridor lies just north of the Deserado Mine permit area and may encroach upon lease by application and proposed mining areas (BLM 2011). Also, there are historic coal mines within or adjacent to the corridor northwest of the Deserado Mine in Township 3 North, Range 102 West (Carroll 2006). Implementation of mitigation measure **GE-1** would lower the risk of encountering subsidence from active or historic mining.

Alternative II-D crosses the Levan Segment of the Wasatch fault zone and the Sugarville area, which are considered to be potentially active. The alternative also crosses landslide prone areas of the Wasatch Plateau. Implementation of mitigation measure **GE-1** would lessen the risks of seismicity and landslides.

Alternative II-D may cross relict shorelines and associated deposits from Lake Bonneville. While these deposits have a PFYC rating of 2, scientifically important fossils have been found in sand and gravel deposits associated with the old shorelines. To protect potential fossil resources, it is recommended that BMPs PAL-1 through PAL-5 and design options TWE-4, TWE-38, and TWE-39 be implemented where the 2-mile transmission line corridor crosses these old shorelines.

Key Parameters Summary

There is an elevated risk that landslide areas crossed by Alternative II-D might result in damage to facilities or interruption of service during the operation of the Project. Seismicity and subsidence risks also are present, but would not be expected to result in damage to facilities or interruption of service during the operation of the Project. Nine oil and gas fields are crossed and active and inactive coal mine areas are crossed that might result in mineral resource access conflicts. Additionally, 129 miles of PFYC Class 5 formations are crossed, which have an elevated risk for impacting fossil resources.

<u>Alternative II-E</u>

Alternative II-E crosses areas of mapped landslides and landslide prone areas. The alternative crosses the Levan Segment of the Wasatch fault zone and the Sugarville area faults, which are considered to be potentially active. Implementation of mitigation measure **GE-1** would lower the risk of landslides and seismicity.

The 2-mile transmission line corridor crosses 5 oil and gas fields in Colorado and Utah.

The Alternative II-E 2-mile transmission line corridor lies just north of the Deserado Mine permit area and may encroach upon lease by application and proposed mining areas (BLM 2011). Also, there are historic coal mines within or adjacent to the corridor northwest of the Deserado Mine in Township 3 North, Range 102 West (Carroll 2006). Implementation of mitigation measure **GE-1** would lower the risk of encountering subsidence from active or historic mining.

Alternative II-E may cross relict shorelines and associated deposits from Lake Bonneville. While these deposits have a PFYC rating of 2, scientifically important fossils have been found in sand and gravel deposits associated with the old shorelines. To protect potential fossil resources, it is recommended that BMPs PAL-1 through PAL-5 and design options TWE-4, TWE-38, and TWE-39 be implemented where the 2-mile transmission line corridor crosses these old shorelines.

Key Parameters Summary

There is an elevated risk that landslide areas crossed by Alternative II-E might result in damage to facilities or interruption of service during the operation of the Project. Seismicity and subsidence risks also are present, but would not be expected to result in damage to facilities or interruption of service during the operation of the Project. Five oil and gas fields are crossed that might result in mineral resource access conflicts. No coal mine permit areas are crossed. Additionally, 113 miles of PFYC Class 5 formations are crossed, which have an elevated risk for impacting fossil resources.

<u>Alternative II-F (Agency Preferred)</u>

Alternative II-F crosses landslide prone areas of the Wasatch Plateau including the Thistle landslide area. The alternative crosses the Levan Segment of the Wasatch fault zone and the Sugarville area faults, which are considered to be potentially active. Implementation of mitigation measure **GE-1** would lower the risk of impacts due to landslides and seismicity.

The 2-mile transmission line corridor crosses 9 oil and gas fields in Colorado and Utah.

Alternative II-F 2-mile transmission line corridor lies just north of the Deserado Mine permit area and may encroach upon lease by application and proposed mining areas (BLM 2011). Also, there are historic coal mines within or adjacent to the corridor northwest of the Deserado Mine in Township 3 North, Range 102 West (Carroll 2006). Implementation of mitigation measure **GE-1** would lower the risk of encountering subsidence from active or historic mining.

Alternative II-F may cross relict shorelines and associated deposits from Lake Bonneville. While these deposits have a PFYC rating of 2, scientifically important fossils have been found in sand and gravel deposits associated with the old shorelines. To protect potential fossil resources, it is recommended that BMPs PAL-1 through PAL-5 and design options TWE-4, TWE-38, and TWE-39 be implemented where the 2-mile transmission line corridor crosses these old shorelines.

Key Parameters Summary

There is an elevated risk that landslide areas crossed by Alternative II-F might result in damage to facilities or interruption of service during the operation of the Project. Seismicity and subsidence risks also are present, but would not be expected to result in damage to facilities or interruption of service during the operation of the Project. Seven oil and gas fields are crossed that might result in mineral resource access conflicts. No coal mine permit areas are crossed. Additionally, 156 miles of PFYC Class 5 formations are crossed, which have an elevated risk for impacting fossil resources.

Cedar Knoll Micro-siting Options 1 and 2

The geologic formations crossed by the Cedar Knoll micro-siting options 1 and 2 would not differ substantially from Alternative II-A. The micro-siting options would not pose a greater risk to paleontological or mineral resources or increased risk from geologic hazards.

Alternative Variation in Region II

Emma Park Alternative Variation

The geologic formations crossed by the Emma Park Alternative Variation would not differ substantially from Alternatives II-E and II-F. The alternative variation would not pose a greater risk to paleontological or mineral resources or increased risk from geologic hazards.

Alternative Connectors in Region II

The Lynndyl Alternative Connector crosses the Scipio and Little Valley faults, which increases the risk to seismic hazards. The connector also crosses an area susceptible to sinkholes in the south end of the Scipio Valley.

Table 3.2-14 summarizes impacts associated with the alternative connectors in Region II.

Table 3.2-14 Summary of Region II Alternative Connector Impacts

Alternative Connector	Analysis	Conclusion
Highway 191 Alternative Connector	There are no identified geologic hazards; no mineral resources; and the connector crosses 3 miles of Class PFYC 5 formations.	There are no apparent unique opportunities or constraints for geologic resources by utilizing this connector.
Castle Dale Alternative Connector	There are no identified geologic hazards; no mineral resources; and no Class 4 or 5 PFYC formations crossed.	There are no apparent unique opportunities or constraints for geologic resources by utilizing this connector.
Price Alternative Connector	There are no identified geologic hazards; no mineral resources; and no Class 4 or 5 PFYC formations crossed.	There are no apparent unique opportunities or constraints for geologic resources by utilizing this connector.
Lynndyl Alternative Connector (Alternatives II-B and II-C)	Scipio and Little Valley faults increase seismic risk; low landslide risk; higher subsidence risk; 2 miles of Class 5 PFYC formations crossed.	There are no apparent unique opportunities or constraints for geologic resources by utilizing this connector.
IPP East Alternative Connector (Alternatives II-A and II-B)	There are no identified geologic hazards; no mineral resources; and no Class 5 PFYC formations crossed. Crosses less than 1 mile of Lake Bonneville deposits.	There are no apparent unique opportunities or constraints for geologic resources by utilizing this connector.

Region II Conclusion

There is some variability between the Region II alternative corridors in terms of geologic hazards although all cross active fault zones, areas of moderate to high landslide risk, and potential subsidence areas (**Table 3.2-13**). Alternative II-C crosses as many as five active fault zones and is potentially the most impacted by seismicity. Alternatives II-D, II-E, and II-F each cross 2 active fault zones. All of the alternatives cross historic coal mining areas that may pose ground subsidence hazards. Potential impacts to minerals also vary. All the alternatives cross oil and gas fields, but alternatives II-B and II-C cross 15 oil and gas fields, more than twice the number of the other alternatives and may be subject to more siting conflict impacts depending on well spacing and density of related surface facilities. All of the alternatives cross active coal mining areas in Colorado and Utah.

Alternative II-A and II-D may pose greater impacts to paleontological resources in Class 3 and Class 4 formations. Alternative II-A crosses 120 miles of Class 5 formations and Alternative II-D crosses 129 miles of Class 5 formations. Alternative II-F poses the most impact risk to paleontological resources.

There are no appreciable differences between the alternative connectors (**Table 3.2-14**) except the Lynndyl Alternative Connector which crosses potentially active fault zones, an area of sinkhole susceptibility, and 2 miles of PFYC rank 5 formations. The other connectors have no identified concerns for geologic hazards, mineral resources, or paleontological resources.

The micro-siting consideration for the Strawberry IRA would not pose unique opportunities or constraints for Alternate II-A Corridor. The micro-siting consideration for the Cedar Knoll IRA would not pose unique opportunities or constraints for Alternate II-A, II-E, and II-F corridors.

3.2.6.5 Region III

Project construction, operation, and decommission impacts in Region III would be the same as those discussed in Section 3.2.6.2, Impacts Common to All Alternative Routes and Associated Components. **Table 3.2-15** provides a comparison of impacts associated with the alternative routes in Region III.

Table 3.2-15 Summary of Region III Alternative Route Impacts

Parameter	Alternative III-A	Alternative III-B	Alternative III-C
Seismicity	Two active fault zones identified (Escalante Desert Faults and California Wash Fault), low ground motion potential.	One active fault zone identified (Escalante Desert Faults), low ground motion potential.	One active fault zone identified (Escalante Desert Faults), slightly elevated ground motion potential in Lincoln County, Nevada. Potential risk from ground fissures in Dry Lake and Delamar valleys.
Landslides	Landslides pose a slight risk.	Same as Alternative III-A.	Same as Alternative III-A.
Subsidence	Risk of abandoned mine hazards including subsidence associated with historic metal mining, southwest of Milford, Utah.	Same as Alternative III-A.	Same as Alternative III-A.
Mineral Resources	2-mile transmission line corridor crosses near or over the Milford Ballast Rock Quarry and the CS Mining Hidden Treasure copper mine northwest of Milford, Utah. Crosses sand and gravel mining areas in Clark County, Nevada.	Same as Alternative III-A.	Same as Alternative III-A.
Paleontological Resources	PFYC Class 3: 21 miles Class 4: 1 mile Class 5: 4 miles	PFYC Class 3: 12 miles Class 4: 0 miles Class 5: 1 mile	PFYC Class 3: 9 miles Class 4: 0 miles Class 5: 1 mile

<u>Alternative III-A (Applicant Proposed)</u>

The Alternative III-A 2-mile transmission line corridor crosses the Escalante Desert Faults, which are located southeast of the Union Pacific railroad tracks near Thermo siding. The normal faults trend generally to the northeast and cut alluvium and lake sediments (Black and Hecker 1999). It is not certain if these faults extend deeply enough into the subsurface to be considered potential sources for earthquakes. This 2-mile transmission line corridor also crosses the California Wash Fault just west of Moapa, Nevada and the 2-mile transmission line corridor essentially is coincident with the fault zone for about 10 miles along the western flank of Northern Muddy Mountains. The California Wash Fault is a normal fault with the downthrown side to the west (Anderson 1999a). The fault forms the boundary between the basin where California Wash is located and the Muddy Mountains. The deposits cut by the fault indicated movement within the last 15,000 years so the fault is considered to be active.

In most areas covered by the proposed routes in Region III, in a 500-year period, ground motion would range from less than 10 percent of **g** to about 16 percent of **g** in parts of southern Lincoln County, Nevada. Ground motions between 10 and 20 percent of **g**, as shown on **Table 3.2-9**, are not expected to cause damage to well engineered structures. Ground motion risk would be low for Alternative III-A.

The Applicant Proposed Alternative has a slight risk of landslides in western Washington County, Utah, where there is a moderate susceptibility to landslides.

In the Escalante Desert of southwest Utah a potential subsidence hazard has developed as a result of decades of groundwater pumping that has resulted in the formation of earth fissures and subsidence of the ground surface (Lund et al 2005). In the area around Beryl Junction in the southern part of the valley, subsidence has lowered the ground surface by as much as 100 feet and earth fissures have accompanied the subsidence. The north-trending fissures were centered around Beryl Junction and range from 300 to 1300 feet in length. The subsidence and fissuring around Beryl does not appear to pose a concern for the proposed routes since the routes are located at the edges of the valley. Even though subsidence is slight as compared to the maximum (a few inches compared to 100 feet), the hazard does present a risk in this area and mitigation measure **GE-1** should be implemented.

Northeast and southwest of Newcastle, Utah ground cracks have been observed but are believed to be large desiccation cracks and are not related to the groundwater withdrawal except during initial stages of dewatering of the shallow water table when large-scale pumping began over 50 years ago (Lund et al 2005). The Alternative III-A lies near or on areas of ground cracking in the Newcastle area, but based on the conclusion regarding the origin of these cracks (Lund et al. 2005), they do not appear to pose a concern.

Alternative III-A may cross relict shorelines and associated deposits from Lake Bonneville. While these deposits have a PFYC rating of 2, scientifically important fossils have been found in sand and gravel deposits associated with the old shorelines. To protect potential fossil resources, it is recommended that BMPs PAL-1 through PAL-5 and design options TWE-4, TWE-38, and TWE-39 be implemented where the 2-mile transmission line corridor crosses these old shorelines.

Alternative III-A crosses an area of active mining northwest of Milford, Utah in Township 27 South, Range 11 West in the Rocky Range, the northern extension of the historic Star Mining District and sometimes referred to as the North Star district (Butler 1913). The Star and North Star Districts historically produced precious and base metals including gold, silver, copper, and lead beginning in 1870. There are 2 active mines in the Rocky Range portion of the district, one produces crushed rock for railroad ballast (Milford Ballast Rock Quarry; Sections 10, 11, 12, 14, and 15) and the other is a copper mine (CS Mining Hidden Treasure copper mine, sections 7, 8, 17, 20, 21, 22, 28, and 34). In addition to crossing these active mining areas, the alternative crosses abandoned mine areas in the district, some of which have been reclaimed (Gallegos 2009). Notwithstanding the reclamation work in the Star District, there may still be areas of exposed adits and shafts and potential subsidence associated with un-reclaimed mines in the Star District in Townships 27 and 28 South, Range 11 West. Mitigation measure **GE-1** should be implemented in the areas described above to lessen potential conflicts with active mining and to determine the subsidence potential.

The Alternative III-A corridor crosses historic and active mineral districts in Lincoln and Clark Counties, Nevada, but it does not cross active mining areas. The corridor is close to but would not cross the Apex Mine located near the intersection of I-15 and SH 93, in Clark County, Nevada.

Key Parameters Summary

Alternative III-A would cross two fault zones, one area of increased landslide potential, and an area of subsidence due to groundwater withdrawal. None of these would be expected to result in damage to facilities or interruption of service during the operation of the Project. No oil and gas fields are crossed that might result in access conflicts. However there are active and historic mining areas that are crossed near Milford, Utah, which could pose mineral access issues and hazards associated with historic mining. The alternative corridor does not cross active mining areas in Nevada. About 4 miles of high PFYC (Class 5) formations are crossed, therefore crossing these formations constitutes a high risk of loss or damage to scientifically important paleontological resources.

Alternative III-B (Agency Preferred)

The Alternative III-B 2-mile transmission line corridor crosses the north end of the California Wash Fault, but the route's southwest direction across the valley takes it away from the fault. The corridor also crosses the Escalante Desert Faults, which are considered active.

A subsidence area in the Escalante Desert that may possibly affect the Alternative III-B has been documented along the railroad tracks southwest of Milford, Utah. The 2-mile transmission line corridors parallel the railroad tracks in the area and cross areas of subsidence. Maximum subsidence in this area was measured at slightly more than 1.5 inches from 1993 to 1998 in an area southwest of Milford, Utah (Forster 2006). Even though subsidence is slight as compared to the maximum (a few inches compared to 100 feet), the hazard does present a risk in this area and mitigation measure **GE-1** should be implemented.

Alternative III-B may cross relict shorelines and associated deposits from Lake Bonneville. While these deposits have a PFYC rating of 2, scientifically important fossils have been found in sand and gravel deposits associated with the old shorelines. To protect potential fossil resources, it is recommended that BMPs PAL-1 through PAL-5 and design options TWE-4, TWE-38, and TWE-39 be implemented where the 2-mile transmission line corridor crosses these old shorelines.

Alternative III-B crosses an area of active mining northwest of Milford, Utah in Township 27 South, Range 11 West in the Rocky Range, the northern extension of the historic Star Mining District and sometimes referred to as the North Star district (Butler 1913). The Star and North Star Districts historically produced precious and base metals including gold, silver, copper, and lead beginning in 1870. There are 2 active mines in the Rocky Range portion of the district, one produces crushed rock for railroad ballast (Milford Ballast Rock Quarry; Sections 10, 11, 12, 14, and 15) and the other is a copper mine (CS Mining Hidden Treasure copper mine, sections 7, 8, 17, 20, 21, 22, 28, and 34). In addition to crossing these active mining areas, the 2-mile transmission line corridor crosses abandoned mine areas in the district, some of which have been reclaimed (Gallegos 2009). Notwithstanding the reclamation work in the Star District, there may still be areas of exposed adits and shafts and potential subsidence associated with un-reclaimed mines in the Star District in Townships 27 and 28 South, Range 11 West.

Alternative Corridor III-B crosses or is near historic mining districts in Lincoln County (Acoma, Vigo, Gourd Springs), but does not cross active mining areas in the county. The corridor may cross or encroach upon an active sand and gravel operation (Moapa Redi-Mix, Township 14 South, Range 66 East) on the north side of Moapa, Nevada (Hess and Davis 2010). The corridor is close to but would not cross the Apex Mine located near the intersection of I-15 and SH 93, in Clark County, Nevada.

Mitigation measure **GE-1** should be implemented to reduce potential conflicts with active mining and to determine the subsidence potential in historic underground mining areas.

Key Parameters Summary

Alternative III-B would cross one fault zone and one area of slight subsidence risk. Geologic hazards would not be expected to result in damage to facilities or interruption of service during the operation of the Project. No oil and gas fields would be crossed. However there are active and historic mining areas that are crossed near Milford, Utah, which could pose mineral access issues and hazards associated with historic mining. The corridor crosses near a sand and gravel operation near Moapa, Nevada. One mile of formations with high PFYC classifications (Class 5) would be crossed.

<u>Alternative III-C</u>

The Alternative III-C 2-mile transmission line corridor crosses the Escalante Desert Faults, considered to be active (USGS 2006). The corridor also crosses areas of ground fissures located in the southern Delamar Valley and the northern Dry Lake Valley (Swadley 1995). The origin of the fissures is not certain but is thought to either be tectonic or from subsidence. There is evidence that the fissures on the north end of Dry Lake Valley are active whereas the fissures at the south end of the Delamar Valley are inactive. Implementation of mitigation measure **GE-1** would reduce the risk of impacts where Alternative III-C crosses the fissures in Dry Lake and Delamar valleys and the Escalante Desert Faults.

The same subsidence feature southwest of Milford, Utah, and discussed in Alternative III-B, may affect Alternative III-C. Even though subsidence is slight as compared to the maximum (a few inches compared to 100 feet), the hazard does present a risk in this area and mitigation measure **GE-1** should be implemented.

Alternative III-C may cross relict shorelines and associated deposits from Lake Bonneville. While these deposits have a PFYC rating of 2, scientifically important fossils have been found in sand and gravel deposits associated with the old shorelines. To protect potential fossil resources, it is recommended that BMPs PAL-1 through PAL-5 and design options TWE-4, TWE-38, and TWE-39 be implemented where the 2-mile transmission line corridor crosses these old shorelines.

The BLM-managed Oak Springs Summit Trilobite Area is within the Alternative III-C Corridor. A transmission line and facilities built within the corridor must be in accordance with BLM rules concerning stand-offs or buffers from such protected areas.

Alternative III-C crosses an area of active mining northwest of Milford, Utah in Township 27 South, Range 11 West in the Rocky Range, the northern extension of the historic Star Mining District and sometimes referred to as the North Star district (Butler 1913). The Star and North Star Districts historically produced precious and base metals including gold, silver, copper, and lead beginning in 1870. There are 2 active mines in the Rocky Range portion of the district, one produces crushed rock for railroad ballast (Milford Ballast Rock Quarry; Sections 10, 11, 12, 14, and 15) and the other is a copper mine (CS Mining Hidden Treasure copper mine, sections 7, 8, 17, 20, 21, 22, 28, and 34). In addition to crossing these active mining areas, the 2-mile transmission line corridor crosses abandoned mine areas in the district, some of which have been reclaimed (Gallegos 2009). Notwithstanding the reclamation work in the Star District, there may still be areas of exposed adits and shafts and potential subsidence associated with un-reclaimed mines in the Star District in Townships 27 and 28 South, Range 11 West. Mitigation measure **GE-1** should be implemented in the areas described above to lessen potential conflicts with active mining and to determine the subsidence potential.

Alternative Corridor III-C may cross areas of historic mining in Lincoln County Nevada, but would not cross active mine areas. The corridor is close to, but would not cross, the Apex Mine located near the intersection of I-15 and SH 93, in Clark County, Nevada.

Key Parameters Summary

Alternative III-C would cross one area of slight subsidence risk. Geologic hazards would not be expected to result in damage to facilities or interruption of service during the operation of the Project. No oil and gas fields would be crossed. However there are active and historic mining areas that are crossed near Milford, Utah, which could pose mineral access issues and hazards associated with historic mining. The alternative corridor does not cross active mining areas in Nevada. One mile of formations with high PFYC classifications (Class 5) would be crossed.

Alternative Variations in Region III

The Ox Valley East and West alternative variations both cross short areas of elevated PFYC classifications. Through implementation of BMPs and design options discussed in Section 3.2.4.2, Impacts Common to All Alternative Routes and Associated Components, no damage or loss to scientifically important paleontological resources is expected.

Table 3.2-16 provides a comparison of impacts associated with the alternative variations in Region III.

Table 3.2-16 Summary of Region III Alternative Variation Impacts

Alternative Variation	Analysis
Ox Valley East Alternative Variation (Alternative III-A)	2 miles of PFYC Class 5 formations would be crossed by Ox Valley East compared to 1 mile of Class 5 formations crossed by Alternative III-A that it would replace. Moderate landslide susceptibility, no other geologic hazard.
Ox Valley West Alternative Variation (Alternative III-A)	The Ox Valley West Alternative would cross no PFYC Class 5 formations compared to 1 mile of Class 5 formations crossed by Alternative III-A which it would replace. Moderate landslide susceptibility, no other geologic hazard.
Pinto Alternative Variation (Alternative III-A)	The Pinto Valley Alternative Variation would cross 3 miles of PFYC Class 5 formations compared to 1 mile of Class 5 formations crossed by Alternative III-A which it would replace. Moderate landslide susceptibility, no other geologic hazard.

Alternative Connectors in Region III

There are no identified geologic hazards or mineral resources associated with the Moapa Alternative Connector. The connector does cross less than 1 mile of undivided Moenkopi and Thaynes Formations. The Moenkopi is considered to be PFYC 3, a moderate potential for paleontological resources.

Table 3.2-17 summarizes impacts associated with the alternative connectors in Region III.

Table 3.2-17 Summary of Region III Alternative Connector Impacts

Alternative Connector	Analysis	Conclusion
Avon Alternative Connector	There are no identified geologic hazards; no mineral resources; and no Class 4 or 5 PFYC formations crossed.	There are no apparent unique opportunities or constraints for geologic resources by utilizing this connector.
Moapa Alternative Connector	There are no identified geologic hazards; no mineral resources; and does not cross PFYC Class 3 or 5 formations.	There are no apparent unique opportunities or constraints for geologic resources by utilizing this connector except for very low risk to fossil resources.

Alternative Ground Electrode Systems in Region III

The southern ground electrode system would be necessary within 100 miles of the southern terminal as discussed in Chapter 2.0. Although the location for this system has not been determined, conceptual locations and connections to the alternative routes have been provided in the project POD. The impacts associated with constructing and operating this system are the same as discussed for Alternative I-A. **Table 3.2-18** summarizes impacts associated with the eight combinations of alternative route and location possibilities for the southern ground electrode system.

Table 3.2-18 Summary of Region III Alternative Ground Electrode System Impacts

Ground Electrode System Name	Analysis
Mormon Mesa-Carp Elgin Rd (Alternative III-A)	Area may include Muddy Creek Formation PFYC 3. No impacts regarding geological hazards or mineral resources.
Halfway Wash-Virgin River (Alternative III-A)	Impacts would be the same as Mormon Mesa Elgin Rd (Alternative III-A).
Halfway Wash East (Alternative III-A)	Impacts would be the same as Mormon Mesa Elgin Rd (Alternative III-A).
Mormon Mesa-Carp Elgin Rd (Alternative III-B)	Impacts would be the same as Mormon Mesa Elgin Rd (Alternative III-A).
Halfway Wash-Virgin River (Alternative III-B)	Impacts would be the same as Mormon Mesa Elgin Rd (Alternative III-A).
Halfway Wash East (Alternative III-B)	Impacts would be the same as Mormon Mesa Elgin Rd (Alternative III-A).
Meadow Valley 1 (Alternative III-C)	Impacts would be the same as Mormon Mesa Elgin Rd (Alternative III-A).

Region III Conclusion

There are no appreciable differences between alternatives in Region III except for a slightly higher seismic risk for Alternative Corridor III-A which crosses 2 potentially active fault zones compared to one fault zone for the other alternatives (**Table 3.2-15**). There are no appreciable differences between the alternative variations (**Table 3.2-16**), the alternative connectors (**Table 3.2-17**), and the ground electrode system alternative (**Table 3.2-18**).

3.2.6.6 Region IV

Project construction, operation, and decommission impacts in Region IV would be the same as those discussed in Section 3.2.6.2, Impacts Common to All Alternative Routes and Associated Components. **Table 3.2-19** provides a comparison of impacts associated with the alternative routes in Region IV.

Table 3.2-19 Summary of Region IV Alternative Route Impacts

Parameter	Alternative IV-A	Alternative IV-B	Alternative IV-C
Seismicity	May cross or is near potentially active faults; low ground motion potential.	Same as Alternative IV-A.	Same as Alternative IV-A.
Landslides	Generally low incidence and moderate susceptibility.	Same as Alternative IV-A.	Same as Alternative IV-A.
Subsidence	Does not cross areas that have subsided due to groundwater withdrawal. Low potential for karst areas.	Same as Alternative IV-A.	Same as Alternative IV-A.
Mineral Resources	Crosses sand and gravel and gypsum mining areas in Clark County, Nevada. No oil and gas.	Same as Alternative IV-A.	Same as Alternative IV-A.

Table 3.2-19 Summary of Region IV Alternative Route Impacts

Parameter	Alternative IV-A	Alternative IV-B	Alternative IV-C
Paleontological Resources	PFYC Class 3: 9 miles; no Class 4 or 5 crossed.	PFYC Class 3: 1 mile; no Class 4 or 5 crossed.	PFYC Class 3: 1 mile; no Class 4 or 5 crossed.

Alternative IV-A (Applicant Proposed and Agency Preferred)

The Alternative IV-A 2-mile transmission line corridor would not be expected to be impacted by landslides or subsidence. It does not cross subsidence areas that have been documented in the Las Vegas area. The corridor crosses the Las Vegas shear zone. It may also cross the south end of the Black Hills fault, but it is not certain because the fault is difficult to define south of the Black Hills where the fault is buried by valley deposits (Zaragoza 2008). Implementation of mitigation measure **GE-1** would reduce or eliminate potential impacts with regard to the potentially active faults and mineral conflicts. The route would cross 9 miles of moderate PFYC (Class 3) formations, but no Class 4 or 5 formations. However, to protect potential fossil resources, it is recommended that BMPs PAL-1 through PAL-5 and design options TWE-4, TWE-38, and TWE-39 be implemented where the 2-mile transmission line corridor crosses these formations.

Alternative IV-B

The Alternative IV-B 2-mile transmission line corridor would not be expected to be impacted by landslides or subsidence. It does not cross areas of subsidence that have been documented in the Las Vegas area. The corridor crosses the Las Vegas shear zone. Southeast of the Black Hills, the corridor parallels the Black Hills fault, but does not cross the fault and would therefore be subjected to ground motion if a strong earthquake was generated along the fault. The corridor may cross areas of mineral potential in the Las Vegas mineral district and it may cross or encroach upon the PABCO mine. Implementation of mitigation measure **GE-1** would reduce or eliminate potential impacts with regard to the potentially active faults and mineral conflicts. The route would cross 1 mile of moderate PFYC (Class 3) formations, but no Class 4 or 5 formations. However, to protect potential fossil resources, it is recommended that BMPs PAL-1 through PAL-5 and design options TWE-4, TWE-38, and TWE-39 be implemented where the 2-mile transmission line corridor crosses these formations.

Alternative IV-C

The Alternative IV-C 2-mile transmission line corridor would not be expected to be impacted by landslides or subsidence. It does not cross areas of subsidence that have been documented in the Las Vegas area. The corridor crosses the Las Vegas shear zone, but the corridor does not cross the Black Hills fault and would therefore be subjected to ground motion if a strong earthquake was generated along the fault. The corridor may cross areas of mineral potential in the Las Vegas mineral district and it may cross or encroach upon the PABCO mine. Implementation of mitigation measure **GE-1** would reduce or eliminate potential impacts with regard to the potentially active faults and mineral conflicts. The route would cross less than 1 mile of moderate PFYC (Class 3) formations, but no Class 4 or 5 formations. No mineral resources would be crossed. To protect potential fossil resources, it is recommended that BMPs PAL-1 through PAL-5 and design options TWE-4, TWE-38, and TWE-39 be implemented where the 2-mile transmission line corridor crosses these formations.

Alternative Variations in Region IV

The Marketplace Alternative Variation would not be expected to be impacted by landslides or subsidence. Southeast of the Black Hills, the corridor parallels the Black Hills fault, but does not cross the fault and would therefore be subjected to ground motion if a strong earthquake was generated along the fault.

Implementation of mitigation measure **GE-1** would reduce or eliminate potential impacts with regard to the potentially active Black Hills fault. No mineral resources would be crossed that might result in loss of economic value or access conflicts. No formations with PFYC classifications greater than 2 would be crossed, therefore no loss or damage to scientifically important paleontological resources is expected.

Table 3.2-20 provides a comparison of impacts associated with the alternative variation in Region IV.

Table 3.2-20 Summary of Region IV Alternative Variation Impacts

Alternative Variation	Analysis
Marketplace Alternative Variation (Alternative IV-B)	Potential seismic hazards due to Black Hills Fault. No impacts to mineral or paleontological resources.

Alternative Connectors in Region IV

None of the alternative connectors would be expected to be impacted by seismicity, landslides, or subsidence that results in damage to facilities or interruption of service. No mineral resources would be crossed that might result in loss of economic value or access conflicts. No formations with PFYC classifications greater than 2 would be crossed except for the Sunrise Mountain Alternative Connector, which would cross 3 miles of the Class 3 Horse Spring Formation.

Table 3.2-21 summarizes impacts associated with the alternative connectors in Region IV.

Table 3.2-21 Summary of Region IV Alternative Connector Impacts

Alternative Connector	Analysis	Advantage
Sunrise Mountain Alternative Connector	There are no identified hazards or mineral resources. Crosses 3 miles of Class 3 Horse Spring Formation.	There are no apparent unique opportunities or constraints for geologic resources by utilizing this connector except for very slight increase in risk to fossil resources.
Lake Las Vegas Alternative Connector	There are no identified hazards, mineral resources, or paleontological resources.	There are no apparent unique opportunities or constraints for geologic resources by utilizing this connector.
Three Kids Mine Alternative Connector	The alternative connector crosses the abandoned Three Kids Mine area that may present hazards including unstable tailing and waste rock piles, steep slopes, and open pits. No other issues identified with regard to minerals or paleontological resources.	The Three Kids Mine presents concerns about the use of this connector route and therefore is a disadvantage to the use of this connector route. Potential contamination risks present a strong disadvantage for this route which may not be mitigated by implementation of mitigation measure **GE-1**.
River Mountains Alternative Connector	There are no identified hazards, mineral resources, or paleontological resources.	There are no apparent unique opportunities or constraints for geologic resources by utilizing this connector.
Railroad Pass Alternative Connector (Alternatives IV-A and IV-B)	The connector may cross or is immediately adjacent to the Black Hills Fault. The connector may cross or encroach upon active sand and gravel mining pits just south of Railroad Pass between SH 93 and the Black Hills. No issues identified for paleontological resources.	Proximity to the potentially active Black Hills Fault may present a disadvantage. Potential seismicity and mineral concerns can be reduced by implementation of mitigation measure **GE-1**.

Region IV Conclusions

There are no distinct differences between the alternatives in Region IV concerning potential impacts due to geologic hazards, mineral resources, and paleontological resources (**Table 3.2-19**). The Marketplace Variation does not present an advantage over Alternative IV-B. There are concerns with hazards and potential contamination for the Three Kids Mine Alternative Connector that place it at a disadvantage as compared to the other connectors in the region. Although the Railroad Pass Connector is close to the potentially active Black Hills Fault, potential impacts are similar to seismic impacts for the alternatives that cross or are adjacent to the fault. The Railroad Pass Connector also may cross or encroach upon gravel mining operations south of Railroad Pass in the end of the El Dorado Valley.

3.2.6.7 Residual Impacts

Geologic Hazards

Although geotechnical design measures would reduce the risk from geological hazards, there is a small risk of damage to facilities in the event of a major geologic event such as a large magnitude earthquake or a landslide the size of the Thistle landslide. The most highly effective mitigation is recognition and avoidance of the particular hazard (Lund et al. 2009). If avoidance is not possible then engineering solutions must be implemented with the awareness that although the risk may be reduced, the engineering solutions cannot totally eliminate the risk, especially for major events.

Paleontological Resources

Even if BMPs and design options are implemented, some scientifically valuable fossils may be disturbed and lost during construction activities. As a consequence, there would be a small incremental loss of fossil material that would be offset by the material that is recovered and preserved for scientific study purposes. Impacts resulting from unauthorized collection and natural weathering and erosion processes would continue.

Mineral Resources

Proper siting and avoidance of mineral producing sites should reduce potential impacts associated with lack of access to mineral resources. However, it is possible that mineral resources may exist directly underneath the right-of-way and some types of resources would not be practically accessible for the life of the project. The types of mineral resources that would be more affected than others would be near-surface mineral material deposits (e.g., common sand, gravel, and stone). Mineable underground coal deposits under the right-of-way may be subject to reduced recovery since a lower extraction rate may have to be applied to maintain support for surface facilities. Oil and gas resources would be less affected because recovery of the resources would be possible even with a minimum stand-off of 250 feet without having to resort to directional drilling. With directional drilling the right-of-way poses even less of a concern for access.

3.2.6.8 Impacts from the No Action Alternative

Current management across the analysis area would be maintained under the No Action Alternative. Under this alternative, there would be no project construction, operation and maintenance, or decommissioning disturbance to impact or be impacted by geologic hazards, mineral resources, or paleontological resources.

3.2.6.9 Irreversible and Irretrievable Commitment of Resources

Geologic Hazards

There would be no irreversible and irretrievable commitments of resources regarding geologic hazards.

Paleontological Resources

Since paleontological resources are nonrenewable, any impacts would render the resource disturbance irreversible and the integrity of the resource irretrievable.

Mineral Resources

The short term preclusion of access to mineral resources would not constitute an irreversible impact since the resources would not be extracted and consumed. However, the impact would be irretrievable for the operational life of the proposed project.

3.2.6.10 Relationship between Local Short-term Uses and Long-term Productivity

Geological Hazards

There are no relationships between local short-term uses and long-term productivity for geological hazards.

Paleontological Resources

Short-term impacts associated with the exposure of any scientifically important fossils from project activities would not adversely impact the long-term potential for discovery of potential fossil resources.

Mineral Resources

The short term effects are not expected to cause long-term impairment to the productivity of mineral resources.